R E P O R T R E S U M E S

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AUTOMOTIVE DIESEL MAINTENANCE 1. UNIT XXVII, I--CATERPILLAR STARTING (PONEY) ENGINE (PART I), II--LEARNING ABOUT BRAKES (PART II).

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THIS MODULE OF A 30-MODULE COURSE IS DESIGNED TO DEVELOP AN UNDERSTANDING OF THE CONSTRUCTION AND OPERATION OF DIESEL ENGINE STARTING ENGINES AND BRAKE SYSTEMS USED ON DIESEL POWERED VEHICLES. TOPICS ARE (1) GENERAL DESCRIPTION, (2) OPERATION, (3) COMBUSTION SPACE AND VALVE ARRANGEMENT (STARTING ENGINES), (4) TYPES OF BRAKES, AND (5) DOUBLE ACTUATED DRUM BRAKES. THE MODULE CONSISTS OF A SELF-INSTRUCTIONAL BRANCH PROGRAMED TRAINING FILM "CATERPILLAR DIESEL STARTING ENGINE" AND OTHER MATERIALS. SEE VT 006 655 FOR FURTHER INFORMATION. MODULES IN THIS SERIES ARE AVAILABLE AS VT 005 684. MODULES FOR "AUTOMOTIVE DIESEL MAINTENANCE 2" ARE AVAILABLE AS VT 005 685 - VT 005 709. THE 2-YEAR PROGRAM OUTLINE FOR "AUTOMOTIVE DIESEL MAINTENANCE 1 AND 2" IS AVAILABLE AS VT 006 006. THE TEXT MATERIAL, TRANSPARENCIES, PROGRAMED TRAINING FILM, AND THE ELECTRONIC TUTOR MAY BE RENTED (FOR $1.75 PER WEEK) OR PURCHASED FROM THE HUMAN ENGINEERING INSTITUTE, HEADQUARTERS AND DEVELOPMENT CENTER, 2341 CARNEGIE AVENUE, CLEVELAND, OHIO 44115. (HC)

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STUDY AND READING MATERIALS

AUTOMOTIVE DIESEL 1 MAINTENANCE

I -- CATERPILLAR STARTING (PONEY) ENGINE (PART I) UNIT XXVII

II -- LEARNING ABOUT BRAKES (PART II)

PART I

SECTION A GENERAL DESCRIPTION

SECTION B OPERATION

SECTION C COMBUSTION SPACE AND VALVE ARRANGEMENT (STARTING ENGINES)

PART II

SECTION A TYPES OF BRAKES

SECTION B DOUBLE ACTUATED DRUM BRAKES

AM 1-27
9/23/66

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This unit is divided into two parts. The first part covers the initial discussion about the CAT starting engine. The second part completes our discussion of brakes and their components.

I - CATERPILLAR STARTING (PONEY) ENGINE (PART I)

SECTION A -- GENERAL DESCRIPTION

The CAT starting engine is of the two cylinder, four cycle, gasoline operated type. It has a magneto ignition system (self contained and does not depend upon a battery for electrical power). The starting engine cooling system is combined with the diesel engine, and also takes its supply of lubricating oil from the diesel, but is separated by a check valve arrangement to prevent both engines pumping oil to the starting engine at the same time.

Besides cranking the diesel engine, it warms the circulating water and lubricating oil. The starting engine exhaust line is piped through the inlet manifold of the diesel engine and warms the intake air to promote easy starting in cold weather.

A bellows is incorporated in the center of the exhaust tube assembly to permit expansion. Each end of the exhaust tube is sealed with a bushing and retainers to minimize the possibility of starting engine exhaust gases, dust or dirt entering the diesel engine through the inlet manifold.

The type discussed in this unit is a vertical 2 3/8" bore and 2 3/8" stroke used on the CAT engines Model D330 and Model D333.

The cylinder block, crankcase, clutch, and brake compartment are included in a single casting. A dry-type air cleaner and down-draft

carburetor mount on an elbow which is cast as part of the cylinder head. The starter pinion and clutch engaging lever is moved to the right for brake and pinion engagement and then to the left to engage the clutch. The starter pinion and clutch cover bolted to the end of the cylinder block has an extension which contains the pinion. A helical ring gear is used on the diesel engine flywheel with the gasoline starting engine. Coolant is circulated through the starting engine from the diesel engine. A recoil starter and magneto are positioned at the front of the engine. A 12 volt electrical starter motor usually is used in place of the recoil starter.

With the recoil starter removed, you can see the crankshaft drive gear. The teeth on the outer circumference of this gear are for the electric starter. The bolt in the center of the gear accommodates the recoil starter latches.

When the recoil starter cable is pulled out, latches in the sheave of the starter engage the bolt and rotate the crankshaft.

When the engine starts or the cable is released, the latches disengage and the cable automatically rewinds.

The magneto is driven off the end of the camshaft at one-half engine speed. Whenever the magneto is installed, the front or No. 1 piston should be at top center on the compression stroke. Install the magneto with the timing marks aligned (matched). The No. 1 spark plug wire goes in the top receptacle of the magneto cap.

On the back of the crankshaft drive gear is a smaller gear and a sprocket. The sprocket drives the camshaft through the link-type chain. The smaller gear meshes with the drives and oil pump gear. The oil will be covered later.

With the carburetor removed, you can see the location of the governor spring. To the left of the spring is the adjusting screw and locknuts. To the right, the spring is attached to a lever which is bolted to the governor fork shaft. A rod connects the outer end of this lever to the carburetor throttle valve. If the engine is to be completely disassembled, be sure to identify the governor spring, since there is another spring in the clutch and pinion control which looks quite like the governor spring, and they could be interchanged through error.

The magneto drive coupling is keyed to the camshaft. Immediately behind the drive coupling is the governor. The governor fork, which is pinned to a vertical shaft in the timing chain housing, is positioned between the governor and the drive coupling.

The governor consists of a sprocket or carrier, four balls which are positioned in slots of this carrier, and a saucer shaped retainer. As the engine speed increases, these balls move outward in the slots due to centrifugal force, push the retainer against the fork, and counteract governor spring tension.

As mentioned earlier, the starting engine oil pump is driven by the small gear located immediately behind the part of the crankshaft gear. The oil pump is accessible after removing its drive gear. It is a two section gear-type pump with a ball and spring relief valve. The valve is not adjustable.

Unlike the older type, the vertical starting engine draws its oil from the diesel engine crankcase. When the starting engine is operating, one section of the oil pump draws oil from the diesel engine crankcase through one of the external lines. The other section of the oil pump scavenges oil from the starting engine oil sump and returns it to the diesel engine crankcase through an exterior tube. Pressure oil is then supplied to the timing chain compartment, to the camshaft, crankshaft, and to the

starting pinion and clutch compartment.

When the diesel engine is running and the starting engine is stopped, pressure oil from the diesel engine pump will open a check valve and supply oil throughout the starting engine lubrication system. When the starting engine is running, oil from the diesel engine pump cannot enter the starting engine. Oil pressure from the starting engine oil pump, plus pressure from the check valve spring, is sufficient to keep the valve closed. An opening is provided in the starting engine sump for oil pumped into the starting engine by the diesel engine to drain back to the diesel engine crankcase.

Overhead valves are used and the valves, along with the rocker arm assemblies, are contained within the cylinder head. The cylinder head can be removed with the starting engine in place when it becomes necessary to service the valves. Forty five degree angle valves are used.

Steel backed aluminum bearings are used in the connecting rods. They can be serviced through the bottom of the cylinder block. Bearings in both standard and .020" undersize are available.

SECTION B -- OPERATION

The brake, starter pinion and clutch are controlled by one single hand lever. As the lever is moved to the right, the clutch is disengaged and the brake is applied. Continued movement to the right engages the starter pinion with the diesel engine flywheel. The lever is then moved all the way back to the left for clutch engagement.

Figure 1 shows the relative position of the clutch and starter pinion assemblies. The automotive type spring engaged clutch at the lower

right is driven by the the crankshaft flywheel. The gear at the lower left is splined to the clutch shaft and drives an idler positioned immediately above it. The idler meshes with the starter pinion drive gear which rotates the starter pinion shaft and pinion through an overrunning clutch. The overrunning clutch, located between the hub of the starter pinion drive gear and shaft, will be described later.

Figure 2 shows when the control lever is moved to apply the brake and engage the pinion, a yoke which fits around the sliding collar assembly at point "A" moves the collar to the left, as shown by the arrows. Attached to the sliding collar is the release bearing, and as the collar is moved to the left, the release bearing contacts the three release levers at "B" and disengages the clutch. Continued movement of the collar against the stationary brake stops rotation of the clutch shaft.

Figure 3 shows how, after the brake is applied, continued movement of the control lever engages the starter pinion by lever action, at "A", against the end of the inner starter pinion shaft. As the shaft and pinion is moved to the left, the plunger in the rotating carrier latches the inner shaft and holds the starter pinion in engagement with the flywheel ring gear. As the diesel engine starts, centrifugal force will overcome the plunger spring and unlatch the inner shaft, allowing the pinion to disengage.

Figure 4 shows the release yoke positioned. Remember, the yoke forces the flange of the sliding collar against the stationary brake shown in the cover at the right. Directly behind the brake is the idler, which transfers power from the drive gear on the end of the clutch shaft in the center of the picture to the starter pinion gear, shown in the right in the top portion of the cover.

In Figure 5, a section of the support bracket has been cut away to show the starter pinion engaging lever. This lever contacts the end of the starter pinion shaft, which can be seen at the right. A bronze bearing

Figure 1

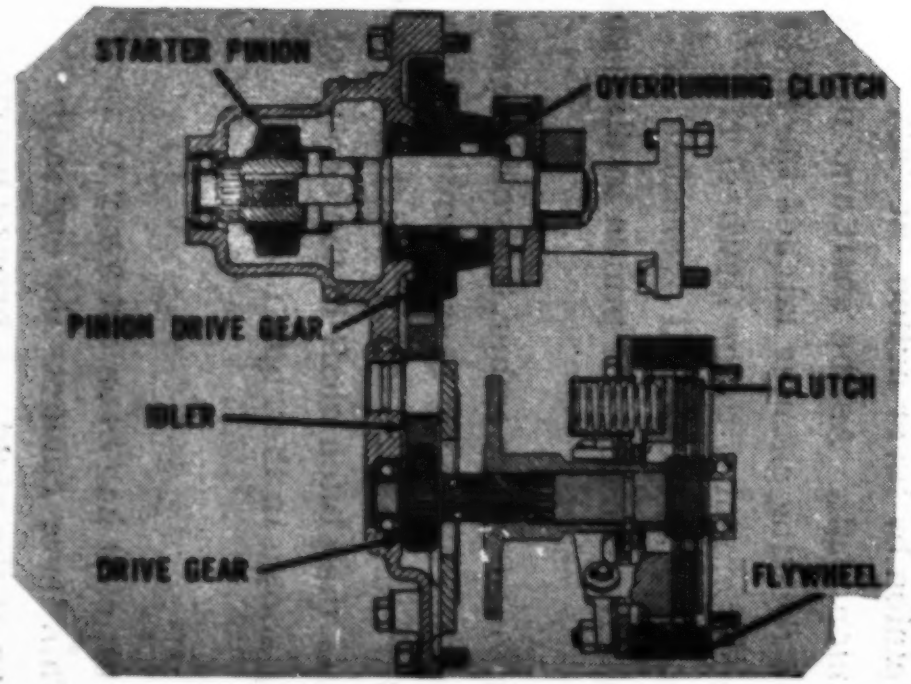


Figure 2

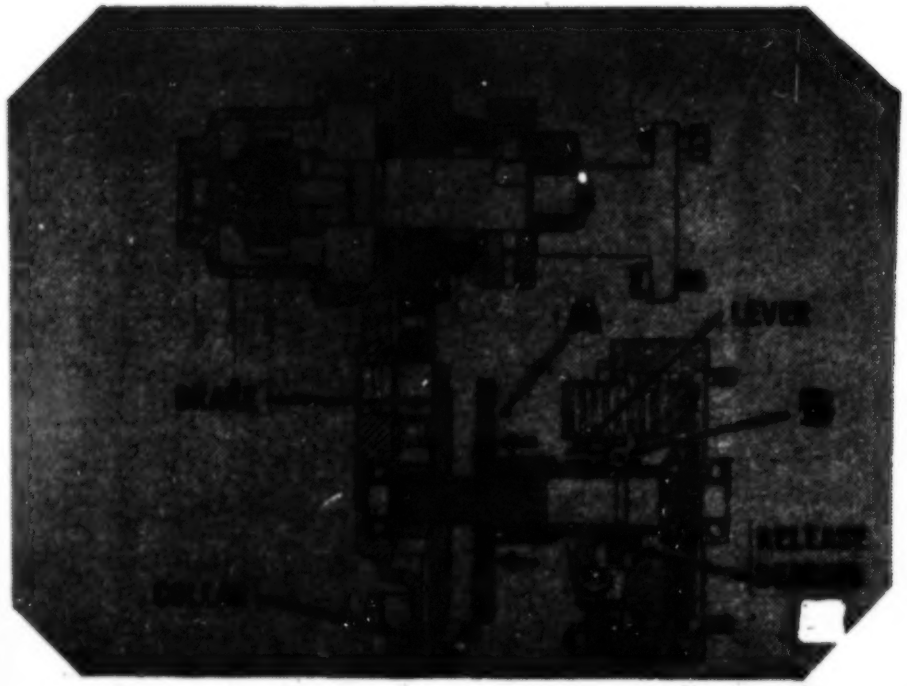
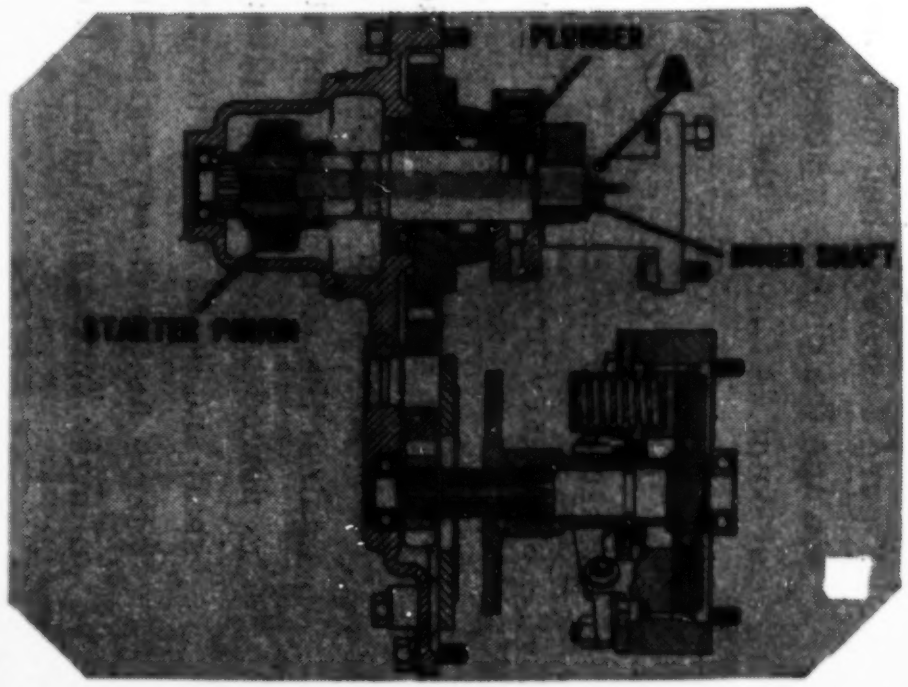


Figure 3



pressed into the bracket supports the inner shaft.

In Figure 6, the clutch assembly has been removed from the flywheel. At the left in this picture is the clutch cover plate with the three engaging springs. This plate is bolted to the flywheel, a part of which can be seen at the right inside the housing.

Next to the cover plate is the pressure plate which, like the center driving disc, meshes with the teeth on the flywheel; see Figure 7. There are two lined driven discs which are splined to the clutch shaft, one on each side of the center drive disc. The inside face of the flywheel also serves as a pressure plate.

The overrunning clutch (see Figure 8) as mentioned previously, is positioned between the starter pinion shaft and the hub of the drive gear. It prevents overspeeding of the starter engine by the diesel engine while the starter pinion is disengaging. It also allows the starter pinion to break away more quickly from the flywheel ring gear. As long as the drive gear and pinion shaft are turning at the same speed, this clutch is locked or engaged. If the starter pinion shaft is turned by the diesel engine faster than the drive gear, the clutch will unlock. The pinion shaft will then turn or speed free and independent of its drive gear.

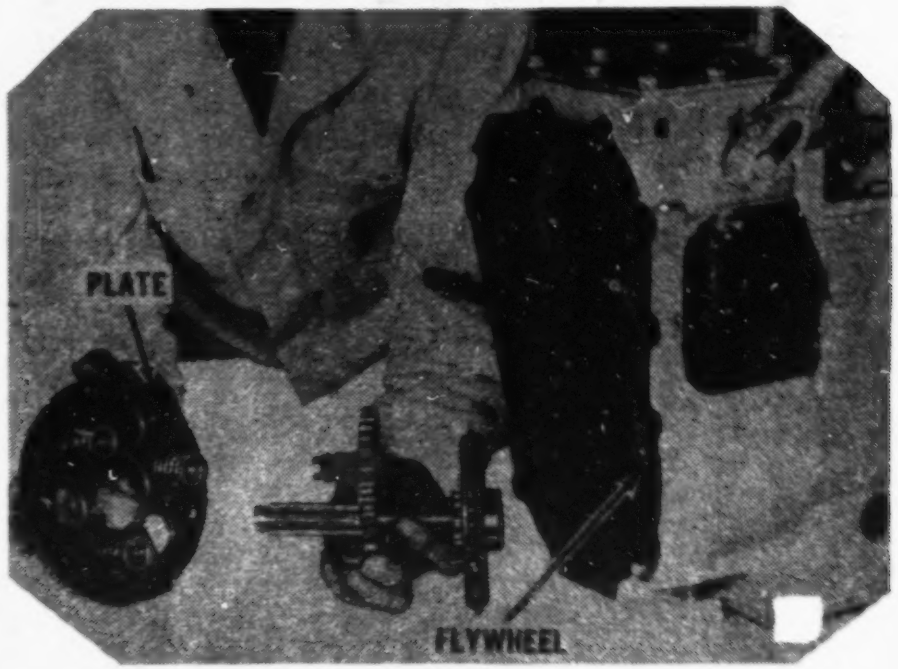
Figure 9 shows the drive gear removed from the pinion shaft and you can see the overrunning clutch located inside the hub of the gear. Shown at the bottom, the clutch consists of an outer and inner ring with the "sprags" positioned in these two rings by a center retainer.

In Figure 10 the "sprags" are machined so dimension "A" is greater than "B". When the starting engine is rotating the clutch through the drive gear, the outer diameters of the "sprags" are forced to the left or counterclockwise.

Figure 4

Figure 5

Figure 6



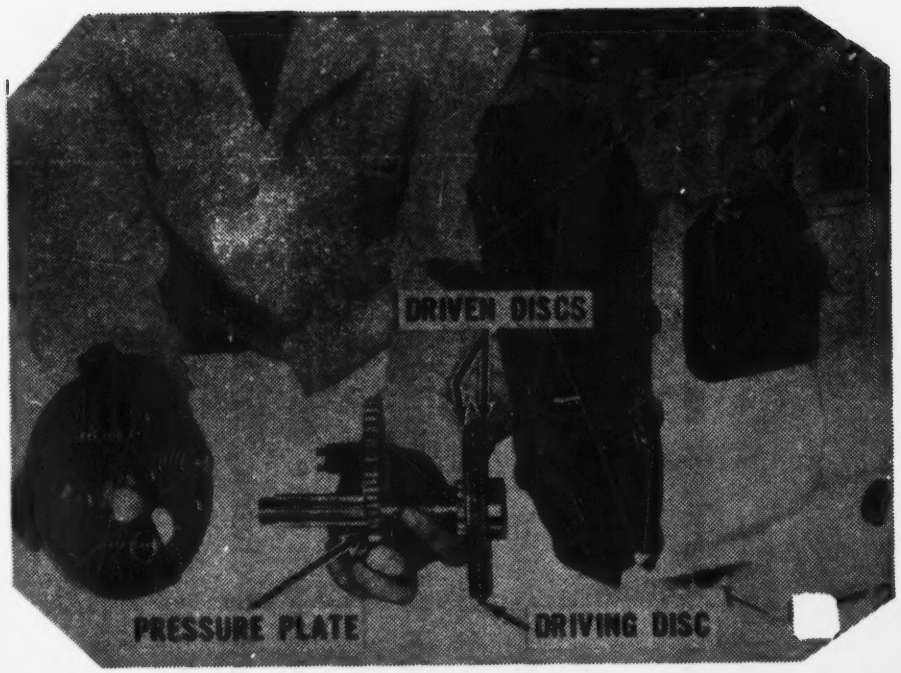


Figure 7

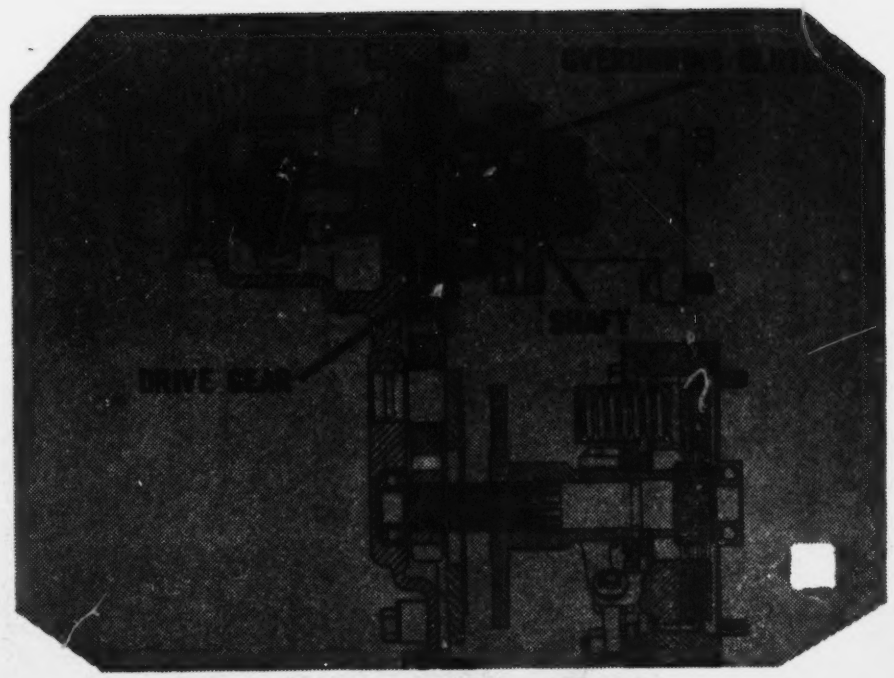


Figure 8

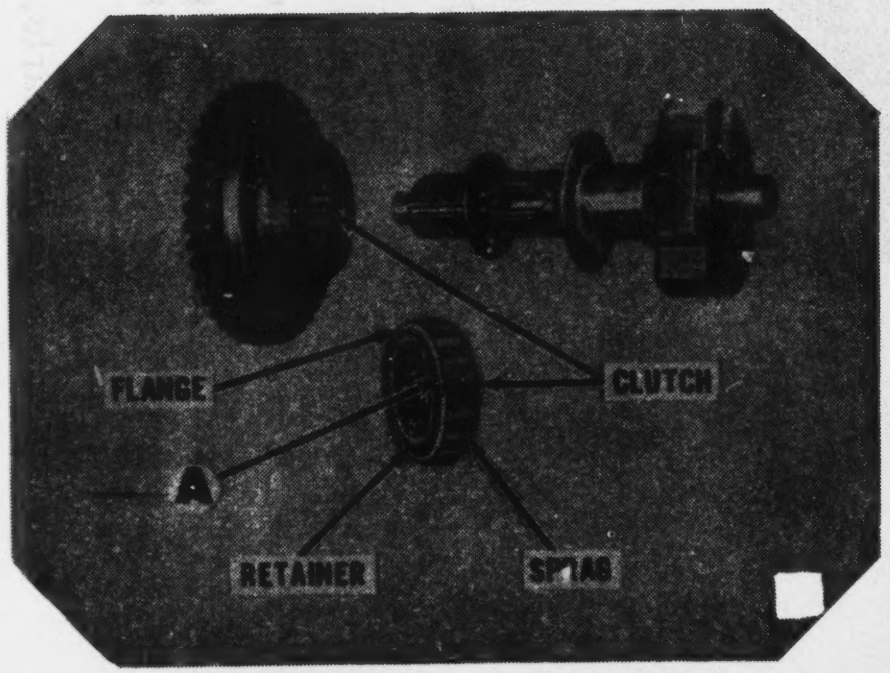


Figure 9

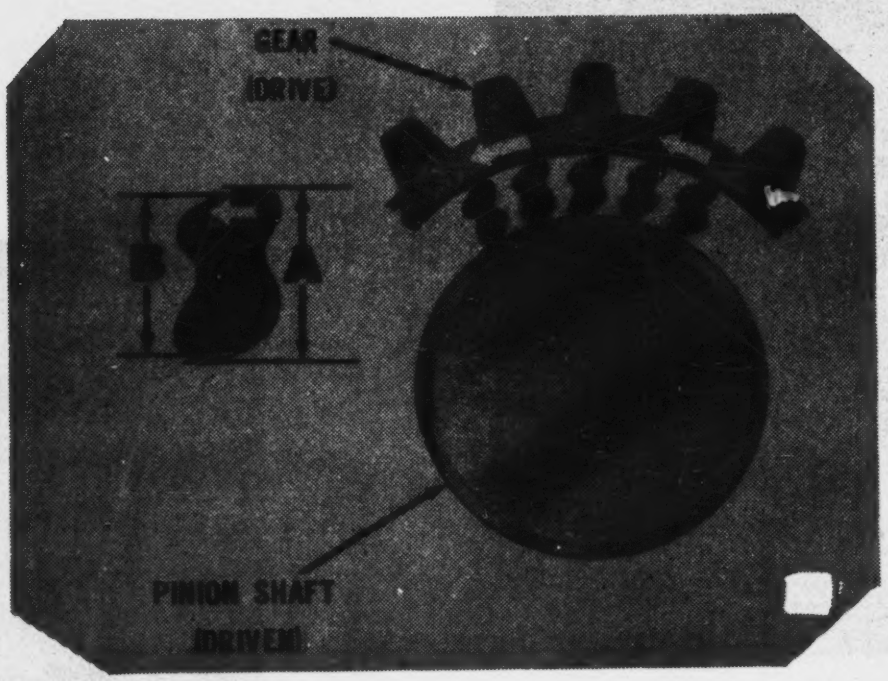


Figure 10

The greater diameter of the "sprags", or diameter "A", then lock the gear and shaft together, and the gear drives the shaft and starter pinion.

When the diesel engine starts, (see Figure 11) it imparts the greater turning force on the shaft, and the inner diameter of the sprags are forced to the left. As the greater diameter of the sprags are now forced away from the gear and shaft, the shaft can speed up independently of the gear speed. This action prevents overspeeding of the gear and starting engine. The action just described is very much like an automobile electrical starting motor with an overrunning clutch, or Bendix drive unit. See Service Manual for adjustments on clutch, brake, and starter pinion controls, shown in Figure 11.

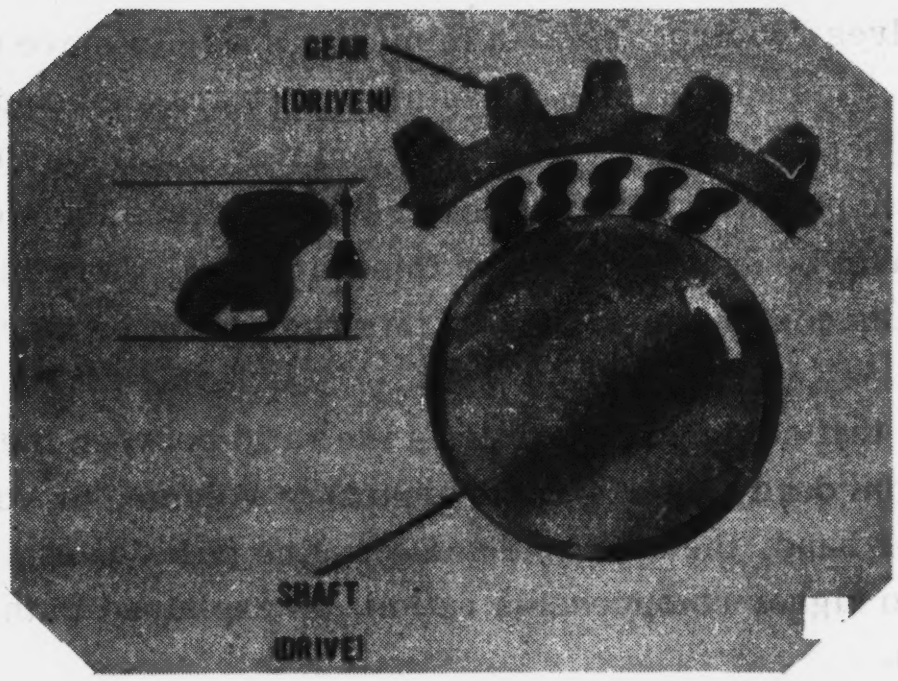


Figure 11

SECTION -- COMBUSTION SPACE AND VALVE ARRANGEMENT (STARTING ENGINES)

VALVE ARRANGEMENT -- The intake and exhaust valves in an engine can be arranged in various positions in the cylinder head or block. These arrangements are termed "L", "T", "I", and "F". The L, I, and F have been used in automotive engines.

In the L-head arrangement the combustion chamber and the cylinder form an inverted L. The intake and exhaust valves are located side by side with all valves for the engine arranged in one line (except for V-8 L-head engines, which are in two lines). This arrangement permits the use of one camshaft to operate all the valves. Since the valve mechanisms are in the block, removal of the cylinder head for major overhaul of the engine is relatively easy. However, in the opinion of many automotive engineers, the L-head engine, while rugged and dependable, is not particularly adapted to higher-compression engines. One reason is

that the valves require a certain minimum space to move up into when they open. This space, plus the minimum clearance required above the top of the piston, determines the minimum possible clearance volume (volume with piston at TDC top dead center). Since the clearance volume cannot be decreased below this minimum, there is a limit to how much the compression ratio of this engine can be increased.

Remember that compression ratio is the ratio between the volume at (BDC) bottom dead center and the clearance volume, or volume at (TDC). On the other hand, the overhead valve engine (I-head) engine is more adaptable to higher compression ratios, as explained in the following paragraphs.

In the I-head, or overhead valve, engine, the valves are carried in the cylinder head. In in-line engines, the valves are in a single row. In V-8 engines, the valves may be arranged in a single row in each bank, or they may be placed in a double row in each bank. Regardless of the arrangement, a single camshaft actuates all valves, with valve lifters, push rods and rocker arms carrying the motion from the cams to the valves.

CAUSE OF KNOCKING -- During normal burning of fuel in the combustion chamber, the spark at the spark plug starts the burning process. A wall of flame spreads out in all direction from the spark (moving outward almost like a rubber balloon being blown up). The wall of flame travels rapidly outward through the compressed mixture until all the charge is burned. The speed with which the flame travels is called the "rate of flame propagation. The movement of the flame wall through the combustion chamber during normal combustion is shown in the row of pictures to the left in Figure 12. During combustion the pressure increases to several hundred (pounds per square inch). It may exceed 700 in some high compression engines.

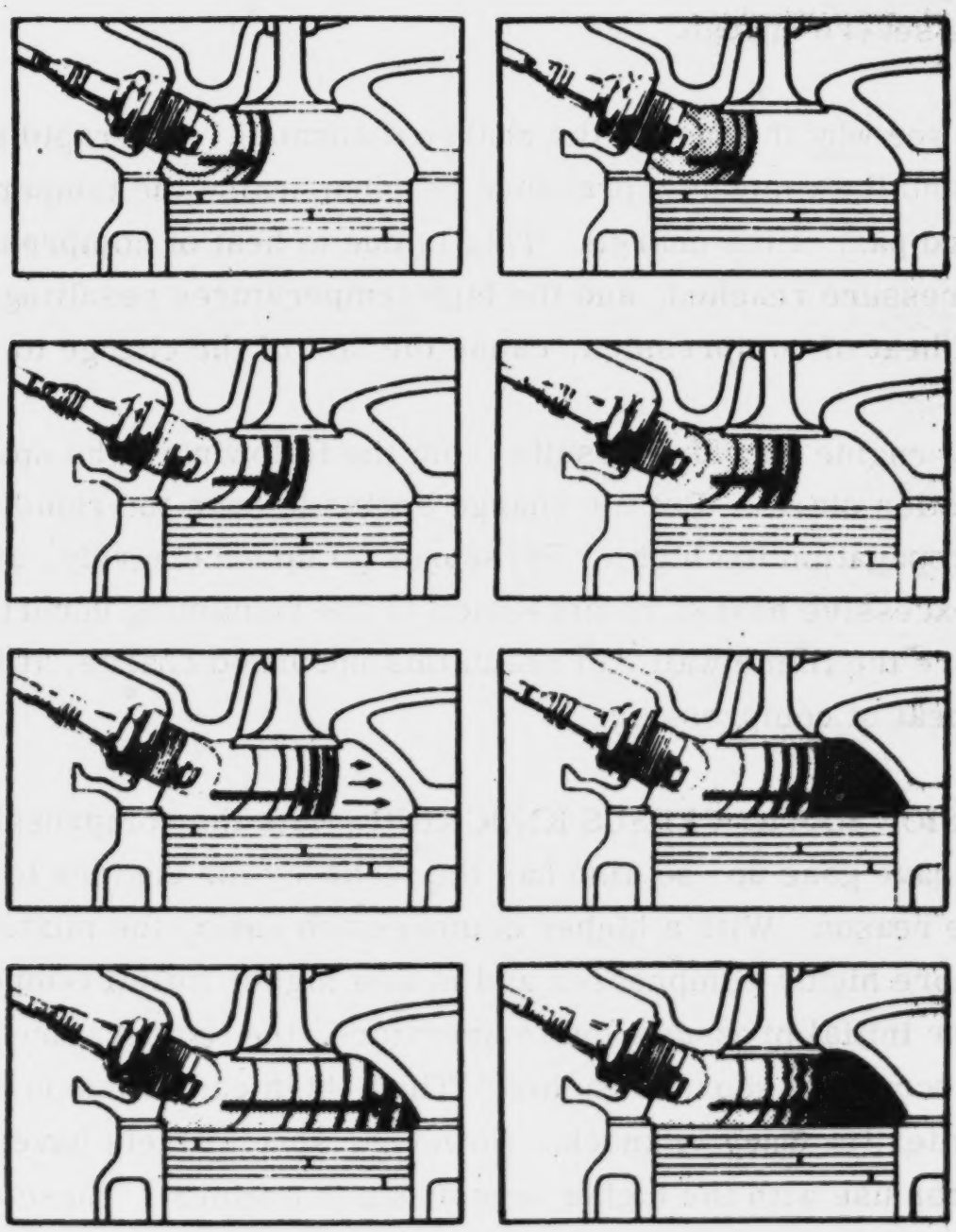


Fig. 12 Flame movement

If the flame travels too rapidly through the mixture (rate of flame propagation is too high), the pressure will increase too rapidly. The effect will be as shown to the right in Figure 12. The rapid pressure increase, and the excessive pressure reached, cause the last of the charge to detonate, or to explode with hammer-like suddenness. The effect is almost the same as if the piston head had been struck a heavy hammer blow. In fact, it sounds as though this had happened. The sudden shock load due to detonation of the last part of the charge increases wear on bearings and may actually break engine parts if the

knocking is severe enough.

Now, let's see why the last of the charge detonates. The rapid pressure increase, and the excessive pressure reached, raise the temperature of the unburned part of the charge. This is due to heat of compression. The high pressure reached, and the high temperatures resulting from the consequent heat of compression, cause the last of the charge to explode.

To sum up, engine knocking results from the following: The spark occurs, and combustion starts. But the charge begins to burn too rapidly (rate of flame propagation too high). Pressures go up excessively, and this produces excessive heat of compression in the remaining unburned charge. Then, before the flame wall can reach this unburned charge, it is set off by the heat of compression.

COMPRESSION RATIO VERSUS KNOCKING -- As the compression ratios of engines have gone up, so also has the tendency for engines to knock. Here is the reason: With a higher compression ratio, the mixture, at TDC, is more highly compressed and is at a higher initial temperature. With higher initial pressure and temperature, the temperature at which detonation occurs is sooner reached. Thus, high compression engines have a greater tendency to knock. However, special fuels have been developed for use with the higher compression engines. These special fuels have a greater resistance to being set off suddenly by heat of compression. They are less apt to explode suddenly, and they depend for their ignition upon the wall of flame traveling through the air-fuel mixture.

FACTORS AFFECTING KNOCKING -- Many mechanical factors in an engine affect knocking. For example, higher air temperatures increase the tendency to knock; higher humidity (or damper air) as well as higher altitudes (or lower density air) reduce the tendency to knock; engine deposits (carbon in combustion chamber) increase knock tendency; advancing the spark increases the tendency to knock; and leaning the

mixture increases the tendency of the engine to knock.

All these factors point up the need for good maintenance of the modern engine. Accumulations of scale in the cooling system, which reduce cooling system efficiency, clogged fuel lines or nozzles in the carburetor, which lean out the mixture, improper ignition timing, engine deposits, all of these increase knocking tendencies of the engine.

PART II -- LEARNING ABOUT BRAKES (PART II)

SECTION A -- TYPES OF BRAKES

DISK BRAKES -- The disk, or caliper, brake has a metal disk instead of a drum and a pair of pads instead of brake shoes. The two pads are located on the two sides of the disk, see Figure 13.

In operation, the pads are forced against the disk by hydraulic or air pressure. The pads, in effect, grip the disk, retarding the movement of the disk and providing braking.

Advantages - Disk brakes are more effective than the drum type because of greater heat dissipation capabilities, despite the larger friction area being utilized. The pad area touches both sides of the disk, and more pads can be utilized around the disk if required. Also, the gripping is done at the outermost perimeter of the disk, not at its axis.

BRAKING THROUGH ELECTRIC RETARDERS -- On some very heavy off-highway equipment vehicles, power for running is obtained by using DC motors attached to each rear wheel. Two such vehicles are the LeLourneau-Westinghouse Haulpak truck and the Unit Rig Lectra-Haul truck. Power for running the DC motors is obtained from a generator, which in turn is driven by a diesel engine.

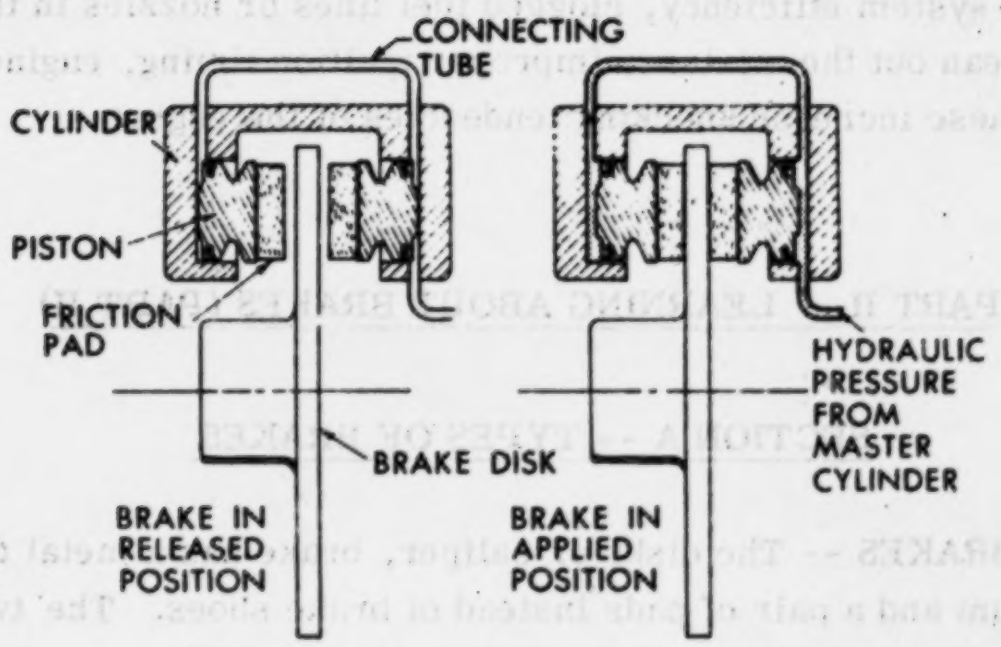


Fig. 13 Operating disk brakes

When current is being sent to each DC motor naturally power is obtained to turn the rear wheels. However, when the operator decelerates and current no longer flows to the DC motors, but the motors still turn due to momentum of the truck, the motors then react as generators. When DC motors are acted upon in this manner, they work against themselves, trying to retard movement, thus giving a braking effect.

As an example of the effectiveness of this particular retarder system, the braking factor involved here is capable of safely controlling a 105 ton vehicle at 13. 5 mph on a 10% down grade.

ADDITIONAL BRAKES -- In addition to the retarder brake system, these two vehicles come equipped with Rockwell Standard air over hydraulic brakes. The latter system is used by many truck manufacturers, (Mack, Euclid, etc.) but this system only, not the retarder system.

Air over hydraulic actuation is accomplished by power packs which convert air to hydraulic pressure and multiply the force. This, in turn, is accomplished by reacting the system air pressure against a large area piston which has a small diameter rod attached. This rod reacts against the hydraulic brake oil, multiplying the total force produced.

Multiplication further occurs at the dual wheel cylinders, where the hydraulic brake oil reacts against two pistons. These pistons, in turn, actuate wedges which force the brake shoes against the drum.

The dual wheel cylinders and wedge actuators produce balanced shoe pressure, utilizing 100% of the braking force as compared to the 70% ordinarily utilized in a cam-type actuacted system. This also results in uniform shoe wear across the face of the lining, rendering uniform braking effort. On Rockwell Standard braking systems, there is a self-adjusting feature which compensates for shoe wear.

OTHER FEATURES - Some trucks are equipped with emergency relay valves which provide protection against low system air pressure by automatically applying the service brakes when main air pressure drops below a pre-determined point.

Still another feature found on certain vehicles is the road condition valve which provides proper front and rear wheel braking forces for variable road conditions. A dash mounted switch selects proper system balance for dry or slippery conditions.

SECTION B -- DOUBLE ACTUATED DRUM BRAKES

As you recall in the last unit (AM 1-26), we discussed drum brakes which were of the single actuated type. Figure 14 shows the double actuated type, where equal pressure is applied to both sides of the shoes by pistons.

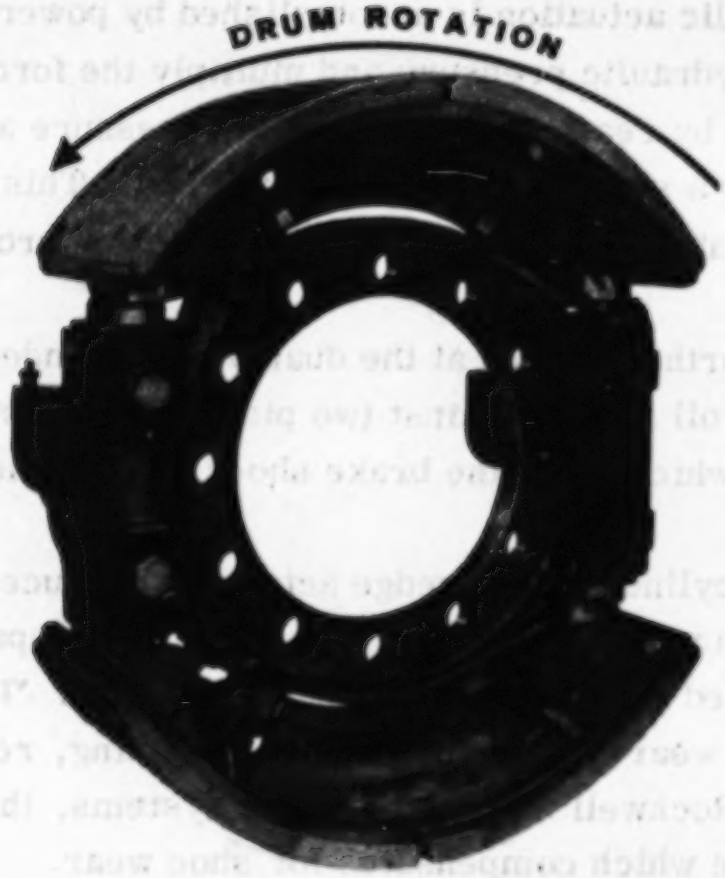


Fig. 14 Double actuated brake

This concludes the brief discussion on vehicle brakes. More about servicing and maintenance of brake systems will be covered in later units.

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AM 1-27D
AM 1-28D
10/12/66

CATERPILLAR DIESEL STARTING ENGINE

Human Engineering Institute

Minn. State Dept. of Ed. Vocational Education

Press A / Check to see that timer is OFF.

1

1

This film is designed to supplement Units No. AM 1-27 & AM 1-28 class text, maintaining the starting engine -- CATERPILLAR Diesel Engine.

The film will be divided into sections, each covering systems and components of the starting engine, lubrication, cooling, ignition, etc...

Press A 2

1

2

The starting engines on most CATERPILLAR Diesel Engines are two cylinder, four cycle, gasoline operated, and have "magneto" ignition systems. The definition in the text for a "magneto" ignition system is a_____.

3 A. battery powered, self contained electrical system

3 B. self contained, battery powered electrical ignition system

4 C. self contained and does not depend upon a battery for electrical power

1

3

No; the text states a "magneto" ignition system is self contained and does not depend upon a battery for electrical power. It generates its own electrical power as it rotates. The "magneto" will be covered in more detail later in the unit.

Press A 4

1

4

OK. The starting engine cooling system is combined with the diesel engine. How is the lubrication system in the starting engine unique as compared to other systems in the engine?

5 A. The starting engine has its own lubrication system and does not depend on the diesel engine for lubrication.

6 B. The starting engine takes its supply of lubricating oil from the diesel engine, but is separated by a check valve.

5 C. There is one common system and both engines pump to the starting engine at the same time with no detrimental effects.

1

5

No, the starting engine lubrication system is combined with the diesel engine, but is separated by a check valve arrangement to prevent both engines pumping oil to the starting engine at the same time.

Press A 6

1

6

OK. Besides cranking the diesel engine, the starting engine does other things as well. Two more important functions of the starting engine are_____.

7 A. besides cranking the diesel engine, it warms the circulating water and lubricating oil

7 B. the starting engine exhaust line runs through the inlet manifold of the diesel engine and warms the intake air to promote easy starting in cold weather

8 C. both "A" and "B" are correct

1

7

No; not only does the starting engine circulate the water and oil through the diesel engine and warms it, but is <u>also</u> warms the inlet air to promote easy starting in cold weather.

Press A for another look at the question 6

8

OK. How is the inlet air for the diesel engine pre-heated by the starting engine exhaust?

9 A. The exhaust is allowed to blow on the inlet manifold of the diesel engine.

9 B. The exhaust from the starting engine is directed to the inlet manifold of the diesel engine before starting is attempted, then the starting engine exhaust is directed to a muffler after it has been determined that the diesel engine inlet manifold is warm enough to attempt a start.

10 C. The starting engine exhaust line runs through the inlet manifold of the diesel engine and warms the intake air to promote easy starting. 1

9

No, inlet air for the diesel engine is pre-heated by the starting engine exhaust line which runs through the inlet manifold of the diesel and warms the intake air. It would be a little impractical to use the diesel engine inlet manifold for the starting engine exhaust system, as dirt and carbon deposits would enter the diesel engine to cause damage.

Press A 10 1

10

OK. Since it is agreed that the starting engine exhaust line runs through the diesel engine inlet manifold, what feature in the system allows for expansion caused by the temperature difference encountered?

11 A. The exhaust tube and inlet manifold are made of a special material that expands in equal amounts and the assembly is stress relieved; expansion is no problem.

12 B. A bellows is incorporated in the center of the exhaust tube assembly to permit expansion.

11 C. Neither of the above "A" or "B" is correct. 1

11

No; one of the above is correct: a bellows is incorporated in the center of the exhaust tube assembly to permit expansion. Each end of the tube is sealed with a bushing and retainers to minimize the possibility of starting engine exhaust gases, dust or dirt entering the diesel engine through the inlet manifold.

Press A 12 1

12

OK. The starting engine discussed in this unit is a vertical 2 3/8" bore and 2 3/8" stroke used on the Caterpillar engines Model D330 and Model D333. The starter pinion and clutch engaging lever is moved to the right for brake and pinion engagement and then to the left to engage the clutch. A _____ gear is used on the diesel engine flywheel with the gasoline starting engine.

13 A. bevel ring

13 B. spiral ring

14 C. helical ring 1

13

No, a helical ring gear is used on diesel engines that have gasoline engines for starting, instead of the electrical starter.

Press A 14 1

14

OK. Coolant is circulated through the starting engine from the diesel engine. A recoil starter and magneto are positioned at the front end of the engine. A(n) _____ may be used in place of the recoil starter.

15 A. impulse type starter

16 B. electrical starting motor

15 C. cartridge type starter 1

15

No; not an impulse or cartridge type starter, but an electrical starting motor may be used instead.

Press A 16 1

16

OK. With the recoil starter removed, you can see the crankshaft drive gear. The teeth on the outer circumference of this gear are for the electric starter. The bolt in the center of the gear accomodates the recoil starter latches. When the recoil starter cable is pulled out, latches in the sheaves of the starter engage the bolt and rotate the crankshaft. When the engine starts or the cable is released, the latches disengage and the cable automatically rewinds.

1

Press A 17

17

The magneto is driven off the end of the ___(1)___ at ___(2)___ engine speed.

19 A. (1) camshaft (2) one-half
18 B. (1) crankshaft (2) same speed as
18 C. (1) timing gear (2) one-half

1

18

No, the magneto is driven off the end of the camshaft at <u>one-half</u> engine speed. Since the camshaft turns at one half crankshaft speed and the engine is a four cycle, the magneto would have to turn at one-half crankshaft (engine) speed.

Press A 19

1

19

OK. On the back of the crankshaft drive gear is a smaller gear and a sprocket. The sprocket drives the camshaft through a _____.

20 A. timing gear arrangement
21 B. link-type chain
20 C. neither of the above are correct

1

20

No, the camshaft is driven through a link-type chain. The smaller gear mentioned in the previous frame is the oil pump drive gear; it will be covered in more detail later in the film.

Press A 21

1

21

With the carburetor removed, you can see the location of the governor spring. To the left of the spring is the adjusting screw and locknut. To the right, the spring is attached to a lever which is bolted to the governor fork shaft. If the engine is to be completely disassembled, be sure to identify the governor spring because_____.

1 A. it is a small calibrated spring and may be easily lost.
23 B. there is another spring in the clutch and pinion control which looks very much like the governor spring.
XC 22
The correct answer must be selected before moving to the next frame.

2

22

You have missed one or more questions in this group and should have the opportunity to go back for a review. Read the questions carefully and take your time in selecting an answer.

Press A 2

2

23

OK. The governor consists of a sprocket or carrier, four balls which are positioned in slots of this carrier, and a saucer shaped retainer. As the engine speed increases, these balls move outward in the slots due to_____.

24 A. increased air pressure developed in the crankcase of the engine
24 B. decreased vacuum in the inlet manifold
25 C. centrifugal force that counteracts governor spring tension

2

24

No, the governor is a centrifugal type. Speed tends to increase centrifugal force, which reacts to limit throttle travel in turn controlling the engine speed.

Press A 25

2

25

OK. The starting engine oil pump is a two section gear-type pump with a ball and spring relief valve. The relief valve is not adjustable (unless the spring is changed). Unlike the older type, the vertical starting engine draws its oil from _____.

26 A. its own crankcase
27 B. the diesel engine crankcase
26 C. the fuel and lubricating oil are mixed and a crankcase is unnecessary

2

26

No, the vertical starting engine draws its oil from the diesel engine crankcase. When the starting engine is operating, one section of the oil pump draws oil from the diesel engine crankcase through one of the external lines. The other section of the oil pump scavenges oil from the starting engine oil pump and returns it to the diesel engine crankcase through an exterior tube (line). Pressure oil is then supplied to the timing chain compartment, to the camshaft, crankshaft, and to the starting pinion and clutch compartment.

Press A 27

2

27

OK. Since both the starting engine and the diesel engine use a common pump, (one crankcase) for lubricating oil, what prevents the diesel engine from pumping oil into the starting engine during the time both the starting engine and diesel engine are running?

28 A. The starting engine runs with higher oil pressure.
28 B. There is no direct connection between the two, except drain back oil.
29 C. There is a check valve that prevents oil from being pumped into the starting engine when both are running.

2

28

No, when the diesel engine is running and the starting engine is stopped, pressure oil from the diesel engine pump will open a check valve and supply oil throughout the starting engine lubrication system. When the starting engine is running, oil from the diesel engine pump cannot enter the starting engine. Oil pressure from the starting engine pump, plus pressure from the check valve spring, is sufficient to keep the valve closed. An opening is provided in the starting engine pump for oil pumped into the starting engine by the diesel engine to drain back to the diesel engine crankcase.

Press A 29

2

29

OK. The valves are contained in the cylinder head and they are the __(1)__ type and are ground at a _____ angle.

31 A. (1) overhead (2) 45 degree
30 B. (1) flathead (2) 30 degree
30 C. (1) rotary (2) 60 degree

2

30

No; overhead valves are used, the valves along with the rocker arm assemblies are contained within the cylinder head. The cylinder head can be removed with the starting engine in place when it becomes necessary to service the valves. Forty-five degree angle valves are used.

Press A 31

2

31

OK. What type connecting rod bearings are used in the starting engine?

33 A. Steel backed aluminum bearings.
32 B. Steel backed babbit bearings.
32 C. Neither of the above answers is correct

2

32

No, steel backed aluminum bearings are used in the connecting rods. They can be serviced through the bottom of the cylinder block. Bearings in standard and .020" under size are available. Several engine manufacturers are using aluminum bearings with success in recent years.

Press A 33

2

33

OK. The brake, starter pinion and clutch, are controlled by one single hand lever. As the lever is moved to the right, the clutch is disengaged and the brake is applied. Continued movement to the right engages the starter pinion with the diesel engine flywheel. The lever is then moved all the way back to the left for clutch engagement. What prevents the starting engine from being driven by the diesel engine flywheel when the diesel engine starts?

34 A. Bendix drive gear
34 B. Starting idler gear
35 C. Overrunning clutch and starter pinion drive gear

2

34

No; overrunning clutch and starter pinion drive gear prevent the starting engine from being driven at a dangerously high speed from the diesel engine flywheel when the diesel engine starts. If the ratio between the starting engine drive pinion and the diesel engine flywheel ring gear were reversed (about 20 to 1) without any means of overrunning or disconnecting them, the starting engine would be turned so fast it would fly apart from centrifugal force.

2

Press A 35

35

OK.

The overruning clutch is positioned between the starter pinion shaft and the hub of the drive gear. It prevents overspeeding of the starter engine by the diesel engine while the starter pinion is disengaging. It allows the starter pinion to break away more quickly from the flywheel ring gear. As long as the drive gear and pinion shaft are turning at the same speed the clutch is locked or engaged. If the starter pinion shaft is turned by the diesel engine faster than the drive gear, the clutch will unlock. The pinion shaft will then turn or speed free and independent of its drive gear.

Press A 36

2

36

Valve arrangement -- The intake and exhaust valves in an engine can be arranged in various positions in the cylinder head or block. These arrangements are termed "L", "T", "I", and "F". What type valve arrangement does the vertical starting engine described previously in this unit employ?

38 A. "I", called valve-in-head.
37 B. "L", called valve-in-block.
37 C. "F", a combination, one valve in the head and the other in the block.

2

37

No, the vertical starting engine described earlier in this unit is of the "I" type or overhead valve type. The older type starting engine used the "L" valve in block arrangement. The "T" and "F" types are rarely used.

Press A 38

2

38

OK. Cause of knocking. During the normal burning of fuel in the combustion space, the spark at the spark plug starts the burning process. A wall of flame spreads out in all directions from the spark. The speed with which the flame travels is called _____ _____.

39 A. the rate of ignition
39 B. the rate of combustion
40 C. the rate of flame propagation

2

39

No, a wall of flame spreads out in all directions from a spark created by the spark plug (almost like a rubber ballon being blown up). The speed with which the flame travels is called the "rate of flame propagation", defined in Webster as the rate of speed that light or flame travels through space.

If the flame travels too rapidly through the gas/air mixture (rate of flame propagation is too high), the cylinder pressure will increase too rapidly. The effect will be knocking.

Press A 40

2

40

OK. If the flame travels to rapidly through the gas/air mixture (rate of flame propagation is too high), the pressure will increase too rapidly. The rapid pressure increase and the excessive pressure reached cause the last of the charge to _____ with hammerlike suddeness.

41 A. ignite
42 B. detonate or explode
41 C. propagate

2

41

No, detonate or explode is the correct answer for the preceeding question. Detonation or exploding of the fuel/air mixture is conspicuous by the sound of knocking.

Press A 42

2

42

OK. The effect of detonation is almost the same as if the piston head had been struck a heavy blow with a hammer. In fact, it sounds as though this had happened. The sudden shock load due to detonation of the last part of the fuel/air charge increases wear on bearings and may actually _____ if the knocking is severe enough.

43 A. cause the engine to overheat
43 B. cause the engine to lose power
44 C. break engine parts

2

43

No, the sudden shock load due to detonation of the last part of the fuel/air mixture increases wear on bearings and may actually break engine parts if the knocking is severe enough.

Press A 44

2

44

OK. Now, let's see why the last of the charge detonates. The rapid pressure increases and the excessive pressure reached raises the temperature of the unburned part of the air/fuel charge. This is due to heat of compression. The high pressure reached, and the high temperatures resulting from the consequent heat of compression cause _____.

46 A. the last of the charge to explode
B. ignition timing to be advanced automatically
XC-45
(The correct answer must be selected before advancing to the next frame).

3

45

You have missed one or more questions in this section and should go back for a review. Read the questions carefully and take your time in selecting an answer.

Press A 25

3

46

OK. To sum up, the knocking process is as follows: the spark occurs, and combustion starts. The charge begins to burn too rapidly (rate of flame propagation too high). Pressures go up excessively, and this produces excessive heat of compression in the remaining unburned charge. Then, before the flame wall can reach this unburned charge, it is set off by _____.

47 A. high compression pressure
48 B. the heat of compression
47 C. the heat of ignition

3

47

No, the correct answer is heat of compression. The process just described in the preceeding frame is often referred to as pre-ignition knocking. Pre-ignition knocking is more pronounced in high compression engines using inferior (cheap) fuel, and should be discouraged, since progressive damage may be done to the engine.

Press A 48

3

48

OK. As the compression ratios of engines have gone up, so also has the tendency of engines to knock. Thus, high-compression engines have a greater tendency to knock. However, special fuels have been developed for use with high-compression engines. These fuels have a greater resistance to being set off suddenly by heat of compression. They are less apt to _____(1)_____ and they depend for their ignition upon the _____(2)_____ traveling through the air fuel mixture.

50 A. (1) explode suddenly (2) wall of flame
49 B. (1) knock (2) proper ignition timing
49 C. Neither "A" or "B" is correct.

3

49

No; the fuels mentioned in the previous frame have a greater resistance to being set off suddenly by heat of compression. They are less apt to explode suddenly and they depend for their ignition upon the wall of flame traveling through the air-fuel mixture.

Press A 50

3

50

OK. Many mechanical factors in an engine affect knocking. For example, higher air temperatures, higher humidity, higher altitudes, engine deposits, all affect knocking tendencies of an engine. Advancing the spark and leaning the carburetor mixture increase the tendency of an engine to knock. All the above mentioned factors point up the need for _____ _____ in modern engines.

51 A. using the proper grade of fuel
51 B. efficient operation (never overloading etc.)
52 C. good maintenance

3

51

No; with the advancements made in engines in recent years, the engines are more critical to the proper maintenance. And any unusual sounds should be investigated as soon as possible, along with using the proper grade of fuel and operating the engine at the most efficient speed and load.

Press A 52

3

52

OK. Most cranking motors used on Caterpillar diesel engines are not cranking motors but _____.

53 A. starting motors
53 B. starting engines
54 C. gasoline driven starting engines

3

53

No, the starting of most large Caterpillar diesel engines is accomplished by a gasoline driven starting engine. Cranking motors are used on some large diesel engines, they are specially designed heavy duty electric motors made for the specific purpose of cranking internal combustion engines at speeds sufficient to permit their starting.

Press A 54

3

54

OK.

An overruning clutch of some type must be provided in the starting motor or starting engine, to prevent damage from overspeeding by the diesel engine flywheel ring gear. There are three types principally used on Caterpillar diesel engines, they are the Dyer Drive, the Sprag Overrunning Clutch Drive and the Bendix Friction Clutch Drive. The drive units are used on both the electrical starting motors and on the gasoline starting engines.

Press A 55

3

55

The Bendix Drive Assembly is used on air starting systems, as well as gasoline and electrical starters. It accomplishes the same end on either, in providing an automatic means of _____.

56 A. taking up the shock of the starter torque when it engages with the flywheel
56 B. engaging and disengaging the drive pinion with the engine flywheel ring gear
57 C. Both "A" and "B" are correct.

3

56

Yes, both "A" and "B" are correct; the Bendix drive assembly accomplishes both.

Press A 57

3

57

OK. When the starter, (whether it be gasoline, air, or electrical) is not operating, the pinion gear is_____.

59 A. demeshed from the engine flywheel ring gear

58 B. engaged with the engine flywheel but the drive gear is overunning

58 C. turning inside the pinion gear but not engaged with the engine flywheel ring gear

3

58

No, when the starter is not operating, the pinion gear is demeshed from the engine flywheel ring gear. As soon as the starter is actuated, the rotor or armature begins to rotate, picking up speed. The shaft assembly picks up speed with the rotor since it is driven through the drive spring. However, the drive pinion, being a loose fit on the shaft, turns within the pinion, forcing the pinion endwise along the shaft and into mesh with the flywheel ring gear. As the drive pinion reaches the pinion stop on the end of the shaft, it can move out no further and it must rotate with the shaft assembly; so the engine is cranked.

3

Press A 59

59

OK. When a starter is actuated, and the drive pinion is engaged with the flywheel ring gear the drive spring was compressed to take up the shock of engagement. After the engine has started, the flywheel spins the drive pinion more rapidly than the rotor shaft assembly, with the result that_____.

60 A. the drive pinion load is reduced and it spins free

61 B. the drive pinion is backed out of mesh with the flywheel ring gear

60 C. the drive pinion continues to turn, but in the opposite direction

3

60

No; as has been mentioned before, after the engine has started, the flywheel spins the drive pinion more rapidly than the rotor shaft assembly is turning, with the result that the drive pinion is backed out of mesh with the flywheel ring gear.

Press A 61

3

61

Ok. What prevents the pinion from drifting into mesh when the engine is running?

62 A. The angle at which the starter is mounted.

62 B. The friction of the pinion gear on the drive shaft.

63 C. A small anti-drift spring between the drive pinion and the pinion stop.

3

62

No, the correct answer is: a small anti-drift spring between the drive pinion and the pinion stop prevents the pinion from drifting into mesh when the engine is running.

Press A 63

3

63

Spark-ignited engines require a source of electricity, that can be interrupted to produce "sparks" at proper times, to ignite air-fuel mixtures in the engine cylinders.

A magneto is a _____ alternating current generator that can produce the electric source (and interrupt it at the proper time) necessary for spark-ignited engines.

64 A. self rectified

65 B. self contained

64 C. externally rectified

4

64

No; the magneto is a self contained alternating generator that does not depend on outside electrical power.

Press A 65

4

65

OK. One of the basic components of a magneto is the TRANSFORMER. It has a heavy wire primary coil with relatively few windings, when compared with the number of fine windings in the _____ coil that is wound around the primary coil in the same direction.

66 A. ignition
66 B. condenser
67 C. secondary

4

66

No; the transformer has a heavy wire primary coil with relatively few windings when compared with the number of fine windings in the secondary coil that is wound around the primary in the same direction.

Press A 67

4

67

OK. Another component of the magneto is the CONTACT BREAKER (which contains the contact points) is actuated by _____ on the rotor shaft.

69 A. the cam
68 B. magneto action
68 C. the rotor

4

68

No, the contact breaker is actuated by the cam on the rotor shaft. Each of the basic components will be explained in more detail later in the unit.

Press A 69

4

69

OK. Besides the transformer, contact breaker, rotor, and condenser, there is a DISTRIBUTOR that is driven by the rotor shaft, and all components are in a housing that has a removable cap.

One end of the primary wire is grounded on the transformer core, the other end of the primary coil wire is joined by one end of the secondary coil wire and is grounded through the_____.

70 A. rotor
71 B. contact breaker
70 C. distributor

4

70

No, one end of the primary wire is grounded to the transformer core and the other end of the primary wire is joined by one of the secondary coil wire and is grounded through the contact breaker. The points complete or break the circuit in the primary winding, to cause an induced high voltage in the secondary winding, which is directed to the spark plugs by the distributor.

4

Press A 71

71

OK. When the rotor is turning, the north pole of the rotor magnet comes under the core of the transformer and the magnetic flux (lines of force) takes the easy route from the magnetic north to the magnetic south by passing through the _____ of the transformer.

72 A. distributor
72 B. magneto
73 C. laminated metal core

4

72

No; when the rotor is turning, the magnetic flux takes the easy route from the magnetic north to the magnetic south by passing through the laminated metal core.

Press A 73

4

73

OK. The magnetic flux changes its direction through the transformer core with each rotation of the rotor. Magnetic flux also surrounds the coil wire of the transformer and creates electricity in the wires. With no interruptions, the electricity would build up positive and diminish to nothing, change directions, build up negative and diminish to nothing with every revolution of the rotor. In a generator this is known as alternating current (AC) cycle.

4

Press A 74

74

In a magneto an interruption in the cycle occurs when the rotor has turned in the transformer to a position where primary coil voltage build-up is high. At this instant, the cam opens the contact breaker and interrupts the cycle causing a sudden collapse of the magnetic field inducing a high voltage in the secondary windings. The low voltage is magnified by the vast number of fine wires in the secondary coil; the voltage in the secondary coil winding is now thousands of times greater than at the instant the contact breaker opened.

Press A 75

4

75

The instant high voltage builds up in the secondary coil, the distributor is in a position where the contact completes an electrical circuit (through a brush in the distributor cap and through a lead wire) to the_____ _____ in the cylinder head.

76 A. secondary system
77 B. spark plug
76 C. primary system

4

76

No; the high voltage flows from the secondary coil winding to the spark plug in the cylinder head. The high voltage now discharges (sparks) across the gap of the spark plug electrodes, completing the ignition to that cylinder.

Press A 77

4

77

OK. The function of the condenser is to _____.

78 A. store electrical energy for the next cycle
78 B. discharge the energy that is built up when the points are open
79 C. prevent damaging arcs from jumping across the contact breaker as it opens

4

78

No; the function of the condenser is to prevent the contact points from arcing when they open. The condenser collects the rush of electrical energy that would normally discharge across the contact as it opens. When the contact breaker opens wider, the electrical energy absorbed by the condenser discharges back into the primary coil winding, thus adding to the voltage build-up in the secondary coil winding.

Press A 79

4

79

OK. Both the primary and secondary coil wires of the transformer are wound in the same direction. One end of each coil is joined and grounded through the contact breaker. The primary coil becomes additional wire in the secondary coil when the contact breaker opens. In this way, a little more boost in voltage is picked up in the secondary coil as the magnetic flux_____.

F A. builds up
81 B. collapses
XC - 80

(The correct answer must be selected before you can move to the next frame).

4

80

You have missed one or more points in the section just covered and should go back for a review. Read the questions carefully and take your time in selecting an answer.

Press A 63

4

81

OK. When the rpm of the magneto increase, the spark at the spark plug electrodes _____.

82 A. decreases
83 B. intensifies
82 C. remains the same

4

82

No, the spark at the spark plug intensifies as the rpm increases. Some magnetos have impulse couplings on the drive end to increase rotor rpm momentarily when the engine is being cranked. The impulse coupling contributes to easy starting. The trip arm (that actuates the impulse) will disengage when the engine starts.

Press A 83

4

83

OK. Some magnetos have impulse couplings on the drive end, to increase the rotor rpm momentarily when the engine is being cranked. The impulse coupling contributes to easy starting. The trip arm that actuates the impulse will disengage when the engine starts.

When the high voltage discharge can find an easier route to ground, a path to ground usually is established and it is likely that the spark will continue to take this new route to ground. In this event, what happens to the spark at the spark plugs?

85 A. The spark intensity is reduced a l[illegible] amount.
84 B. The spark plug misfires.
84 C. Both "A" and "B" are correct.

4

84

No; the high voltage discharge from the magneto can find an easier route to ground. A path to ground usually is established and it is likely that the spark will continue to take this new route to ground. In this event, the spark plugs will be affected. The spark intensity will be reduced an amount equal to the ground.

Press A 85

4

85

OK. The contact assembly gap is the only adjustment in the magneto. One part of the assembly is a fiber pivot block (sometimes called rubbing block) and the other part is an adjustable contact. When the magneto is operating, high portions of the rotor cam (high point of the cam) rub against the fiber block. When the fiber wears, the contact gap becomes less and it is necessary to_____.

86 A. replace the contact assembly
86 B. replace the fiber pivot block
87 C. adjust the gap

Note: when the magneto switch is off, the magneto is grounded and cannot produce sparks.

4

86

No, as the fiber pivot block wears it becomes necessary to adjust the contact point gap. If the contact assembly becomes burned and pitted, it is necessary to replace the assembly.

Press A 87

4

87

OK. A spark plug must operate in combustion temperatures as high as ___(1)___ degrees F, at 1000 to 2000 sparks per minute, and must withstand pressure as high as ___(2)___ pounds per square inch.

88 A. (1) 5,000 (2) 1,000
88 B. (1) 1,000 to 2,000 (2) 600
89 C. (1) 4,000 (2) 800

4

88

No; a spark plug must operate in combustion temperatures as high as 4,000 degrees F, and withstand pressure as high as 800 pounds per square inch.

Press A 89

4

89

OK. The correct spacing of the spark plug is important because it influences the entire range of engine performance: starting idling, power and speed. Uniformity of all spark plug gaps is extremely important to smooth engine operation. Always check the plug gap on new spark plugs against specifications, before installing them.

On used spark plugs, the electrodes should be filed flat because current is emitted from a sharp corner much more easily than from a blunt or rounded surface. If this maintenance is neglected, up to 30% more voltage is required to fire the spark plug.

Press A 90

4

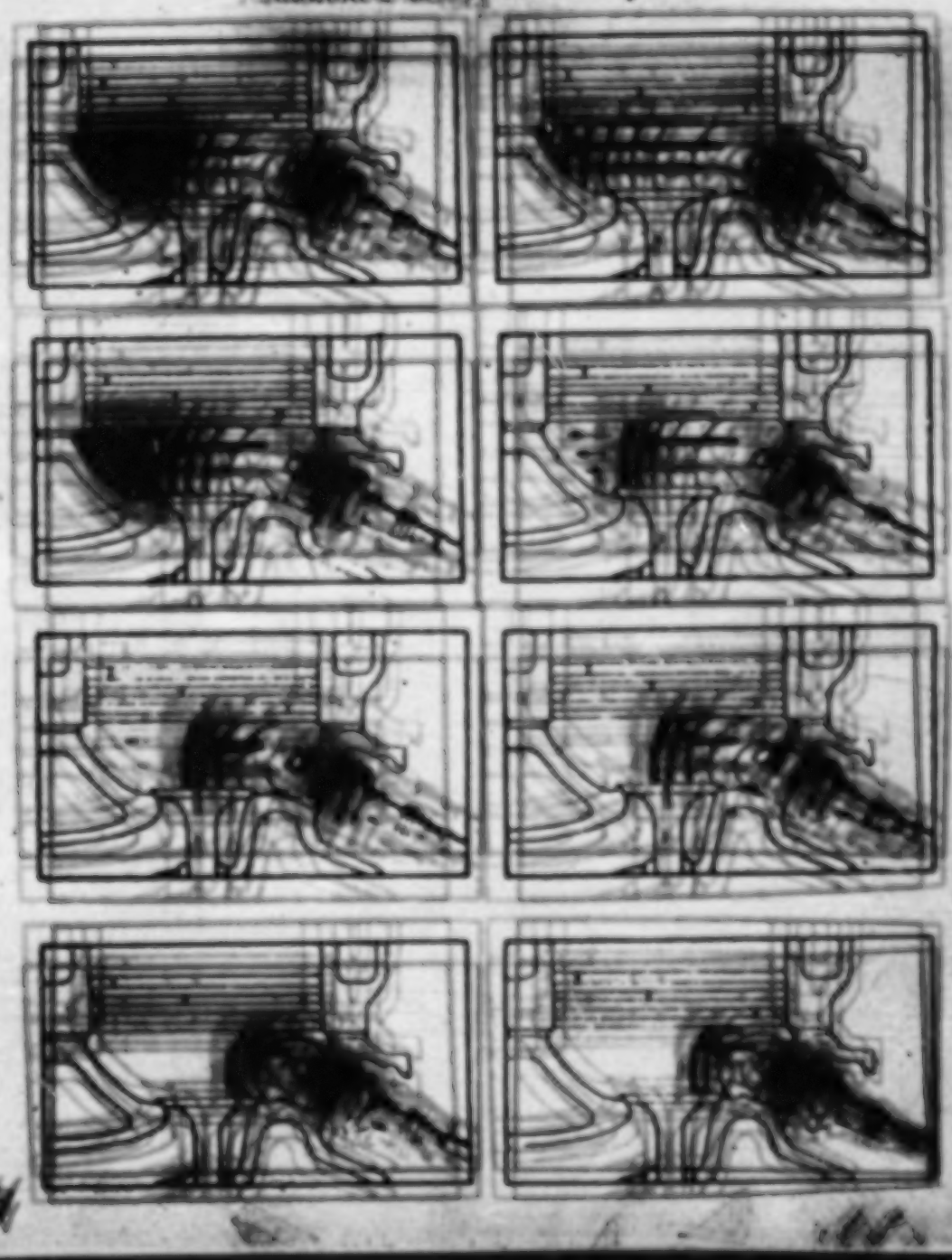
90

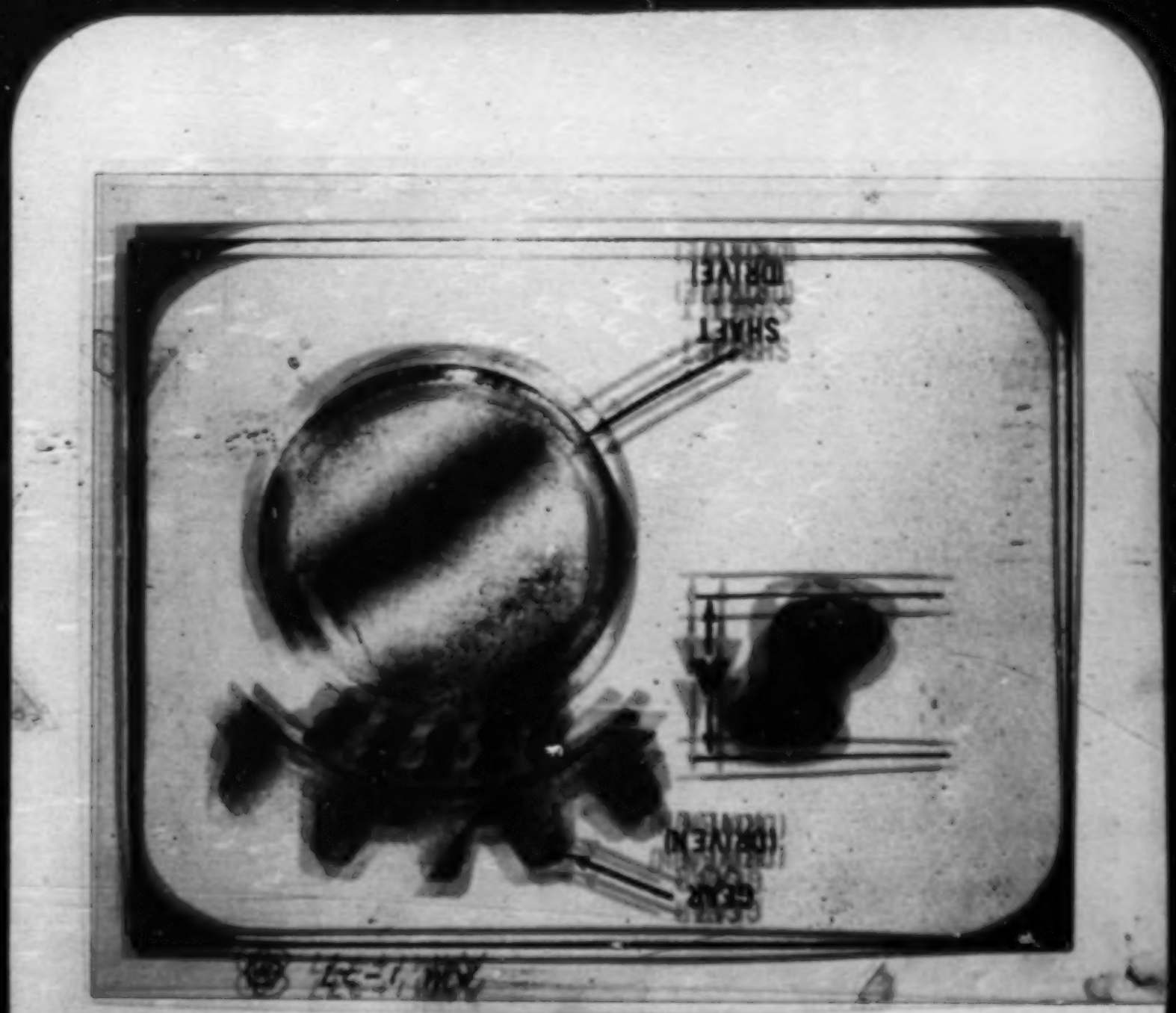
For proper spark plug selection, use the specifications, and cross-reference if necessary. Torque the plugs to specifications to insure proper heat, transfer, and use a thread lubricant.

Congratulations you have completed Unit AM 1-27D & AM 1-28D.

Please Press Rewind

4

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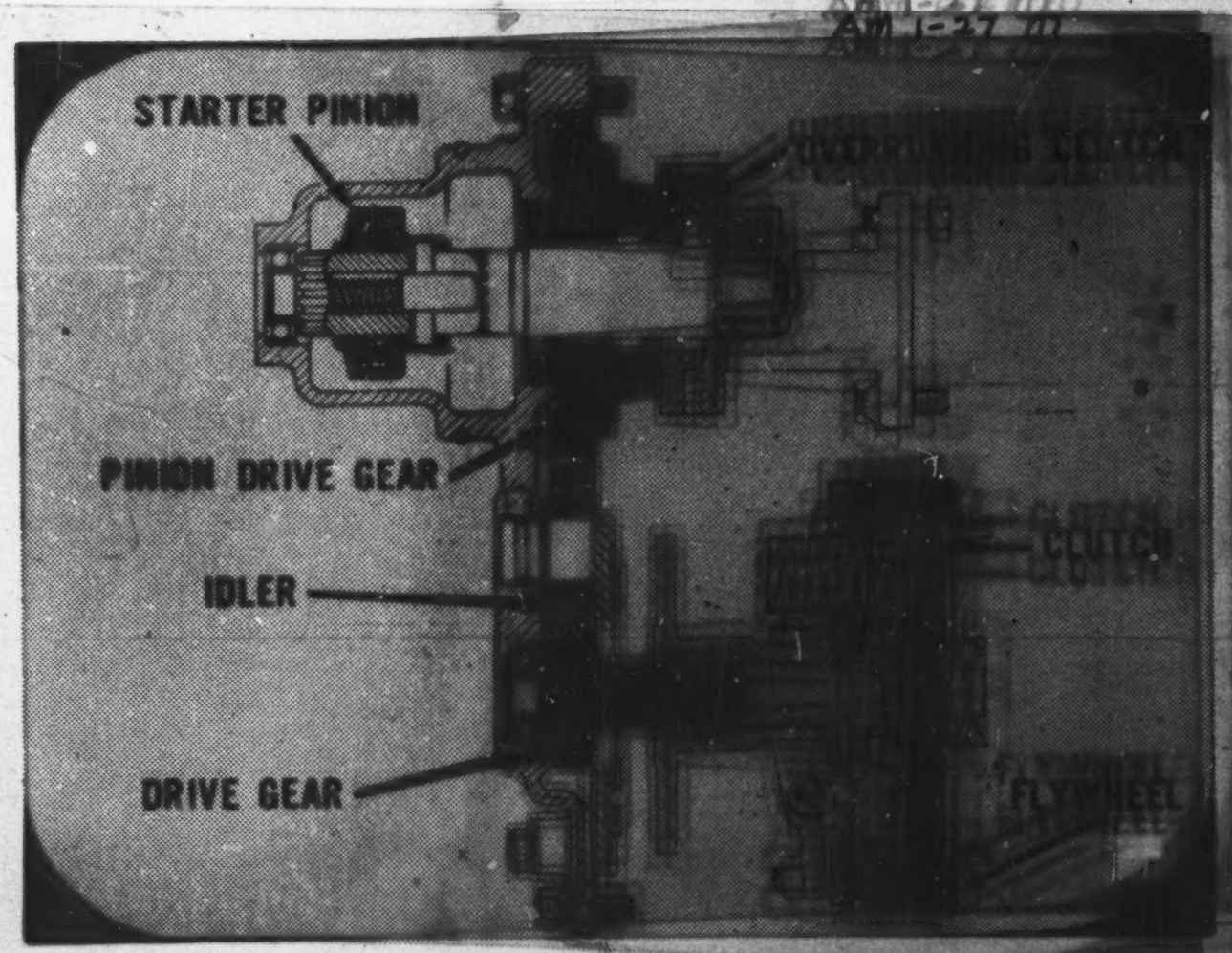
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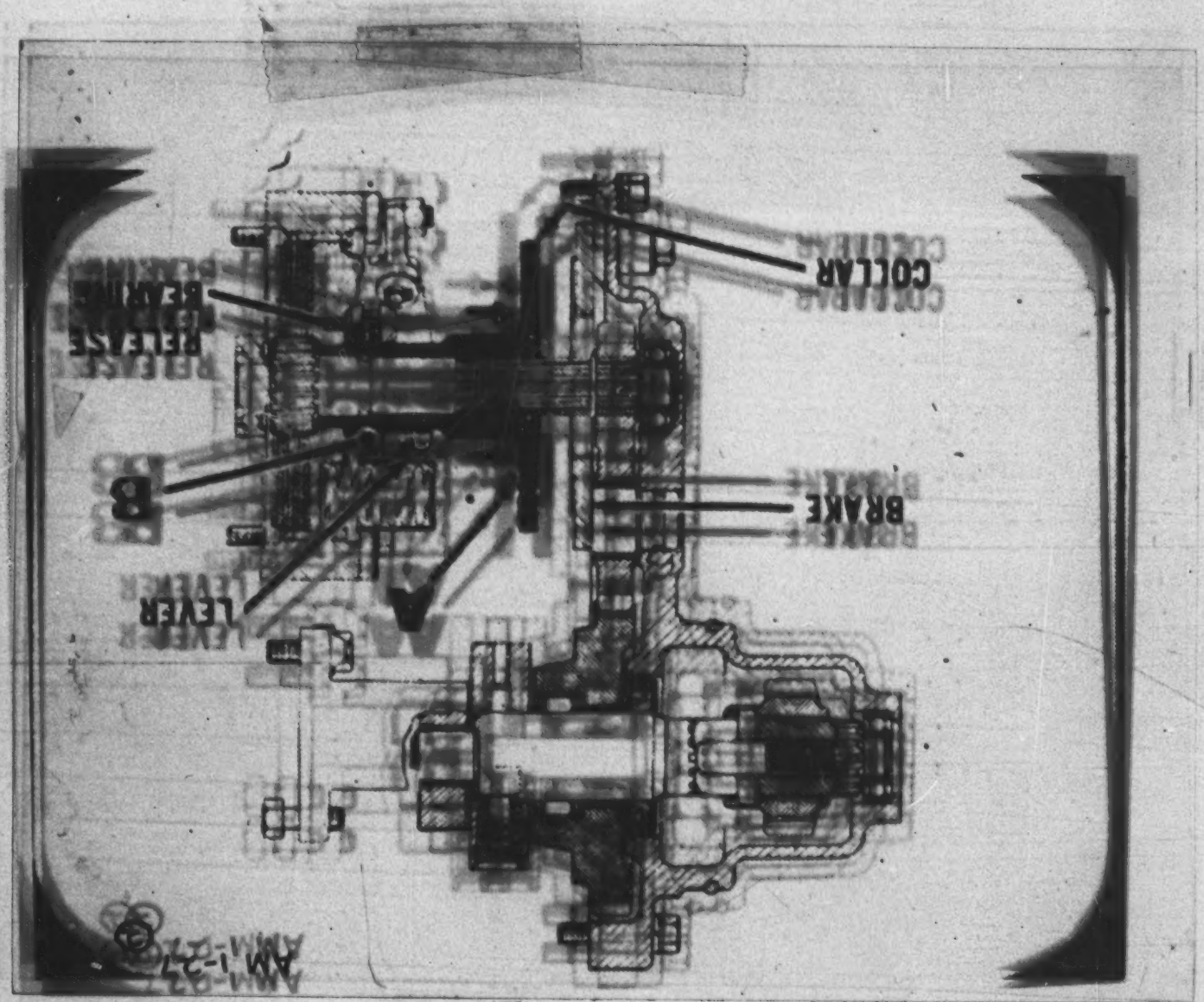
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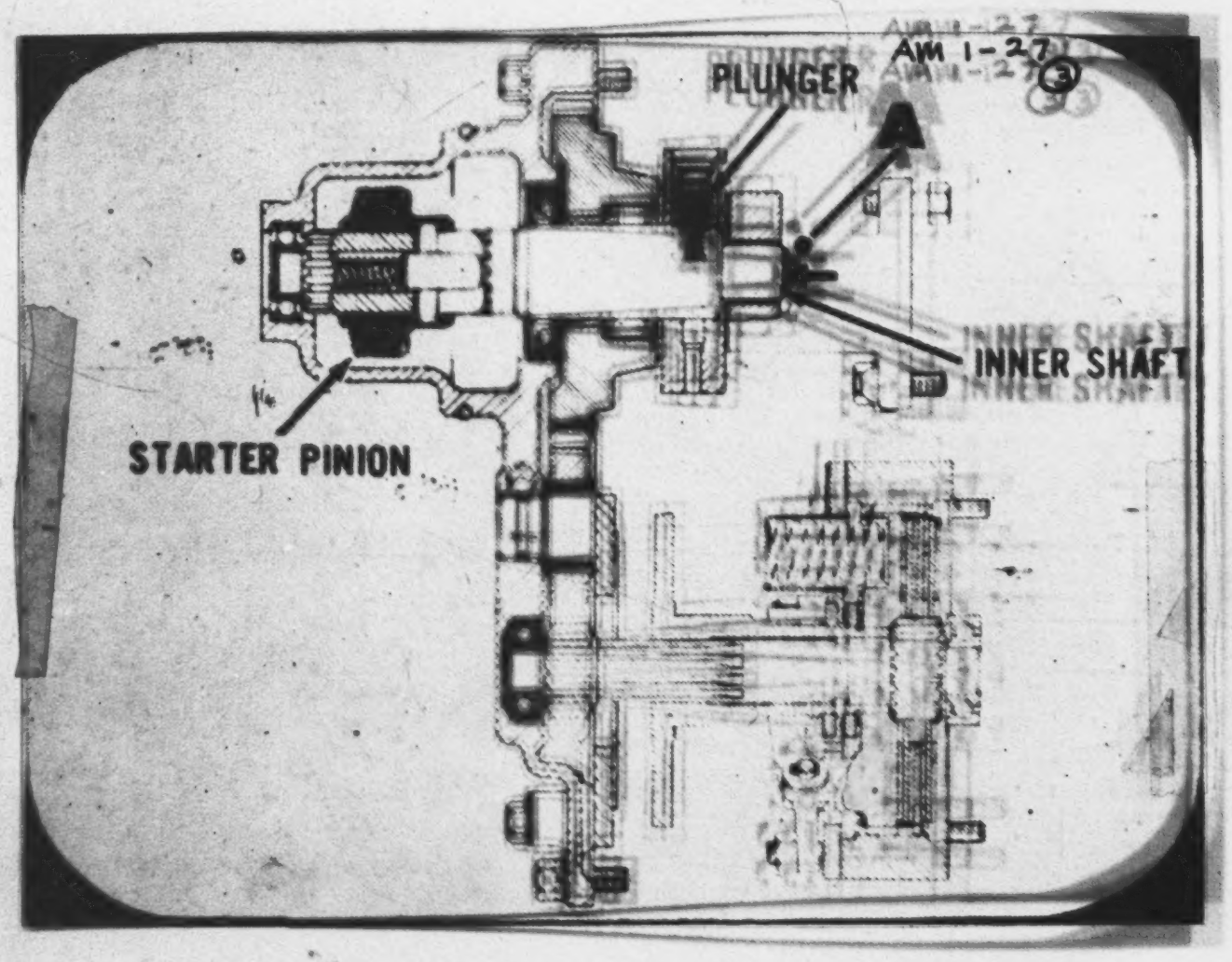
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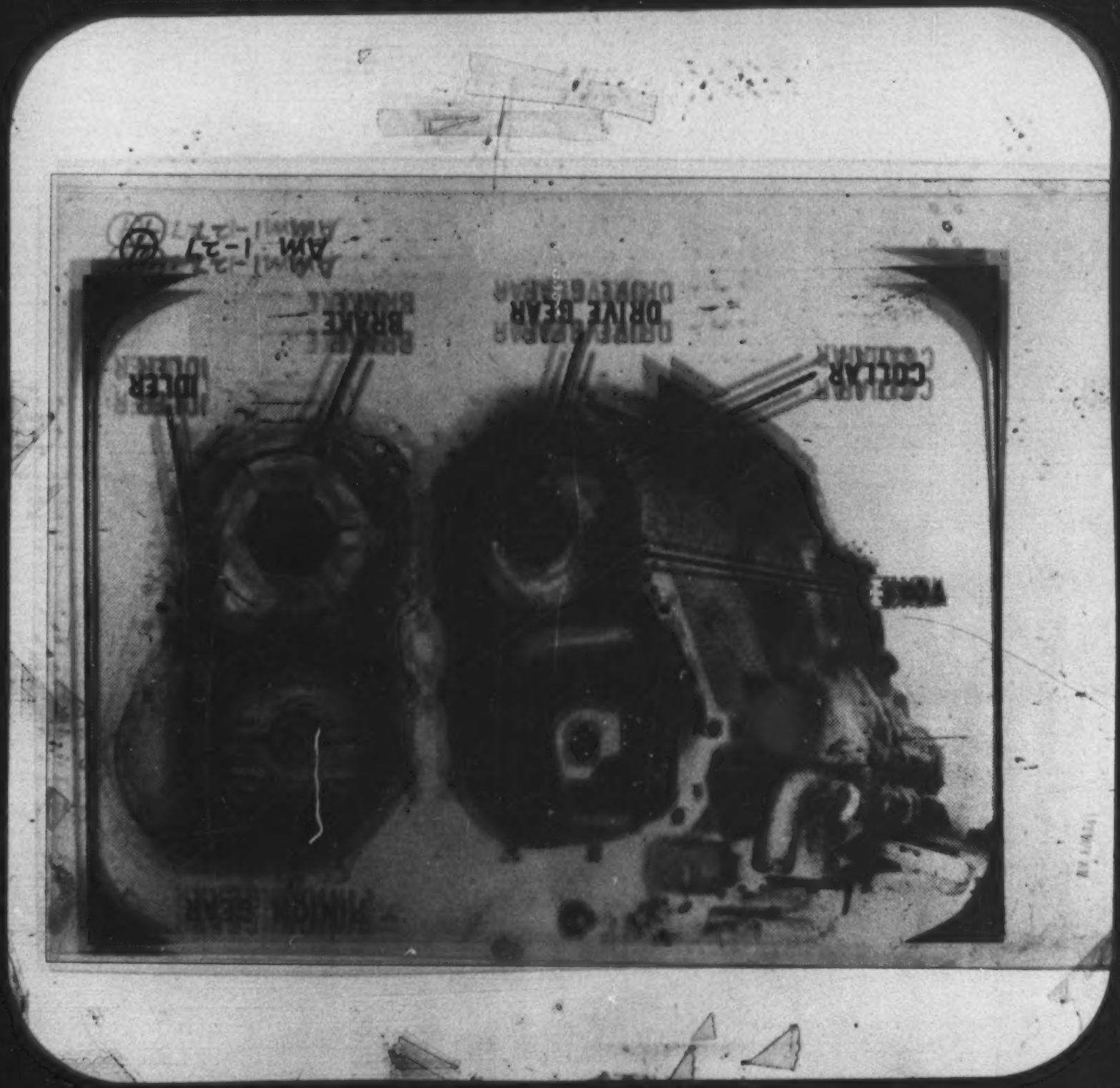
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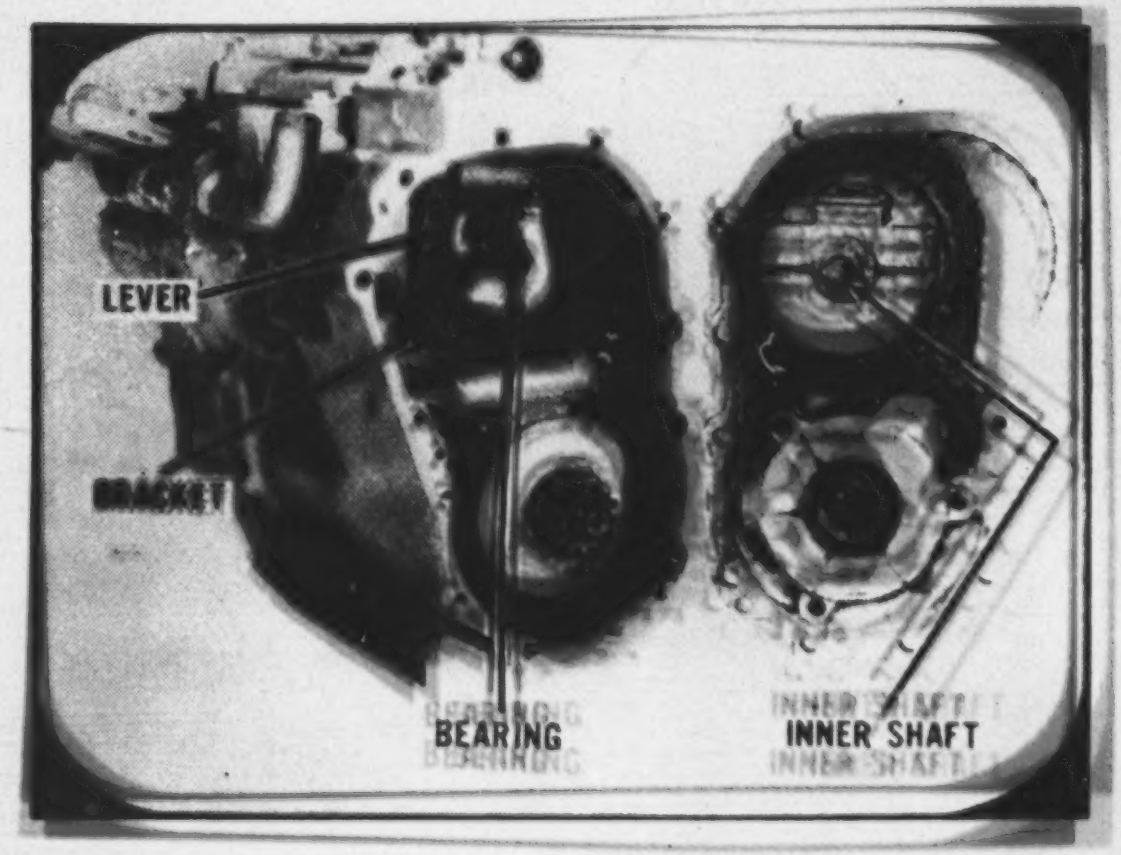
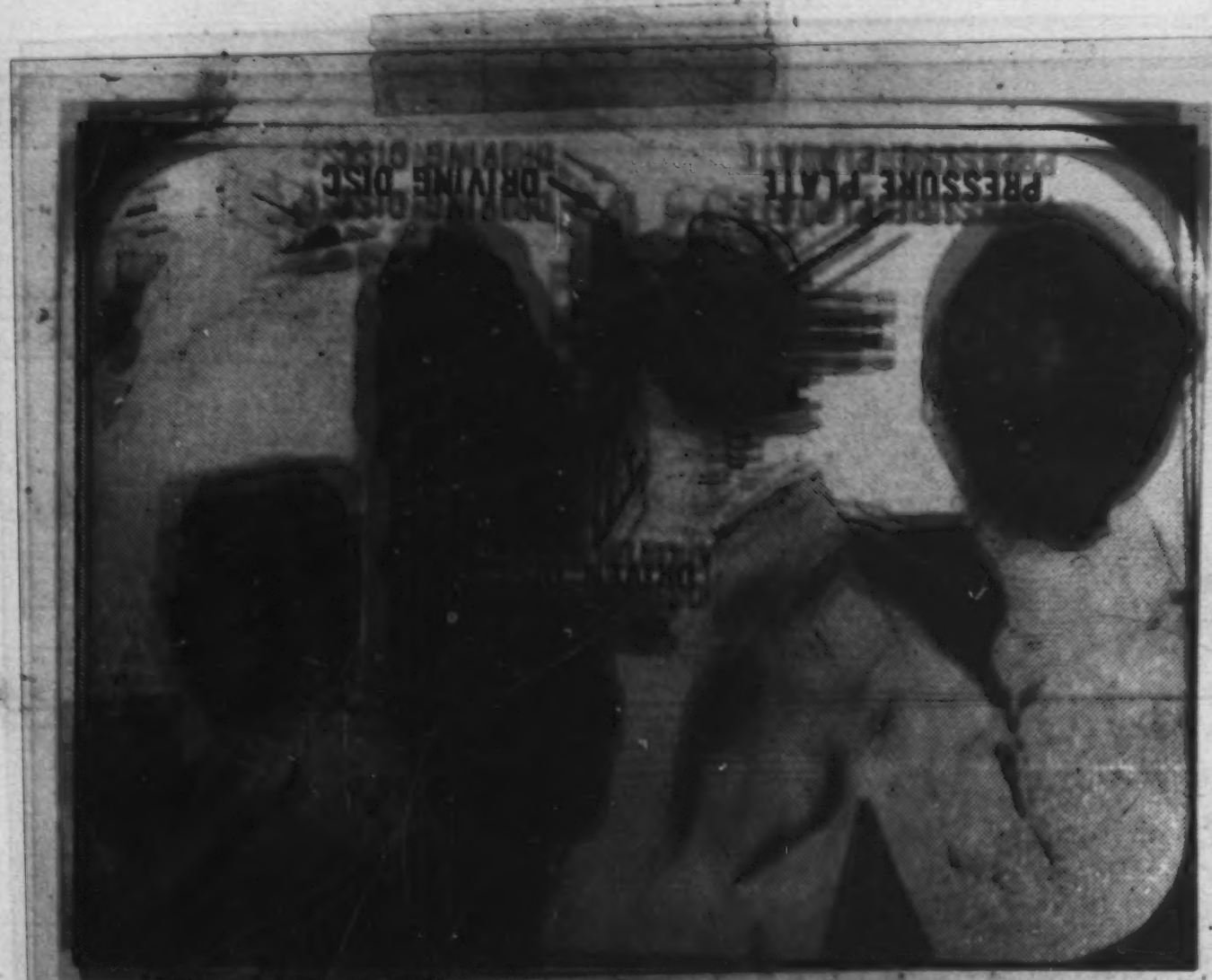
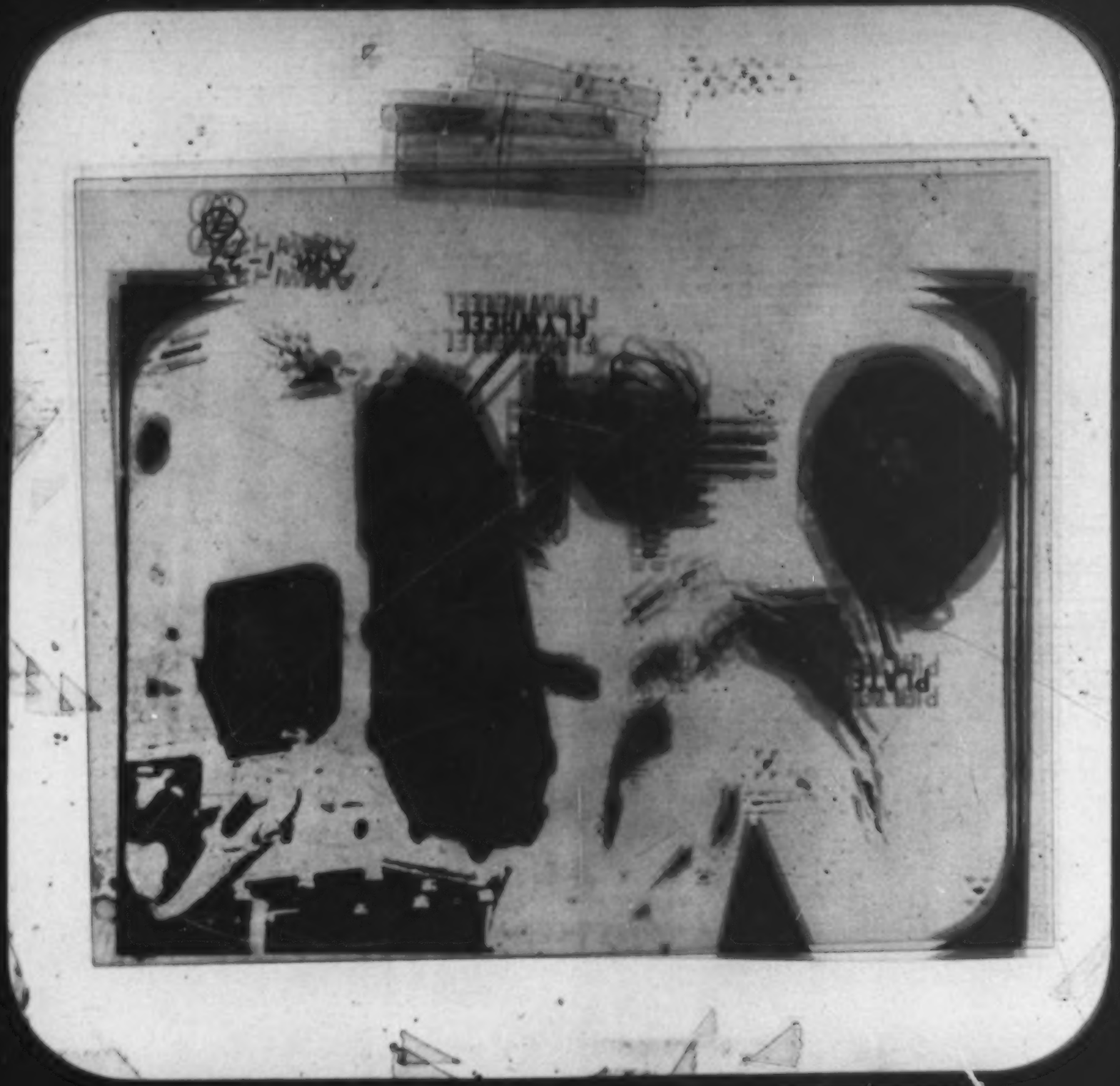
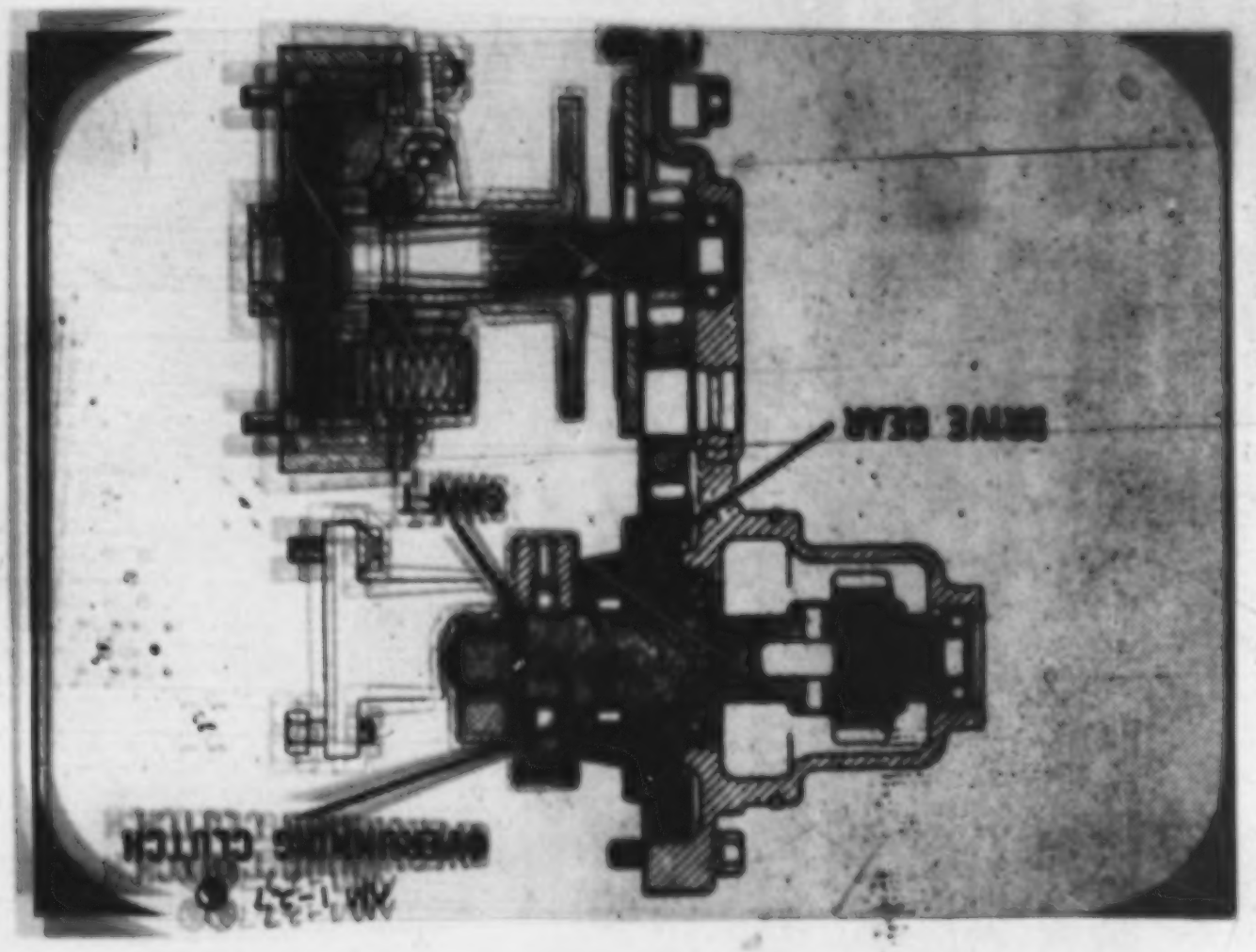
BRAKE
IDLER
COLLAR

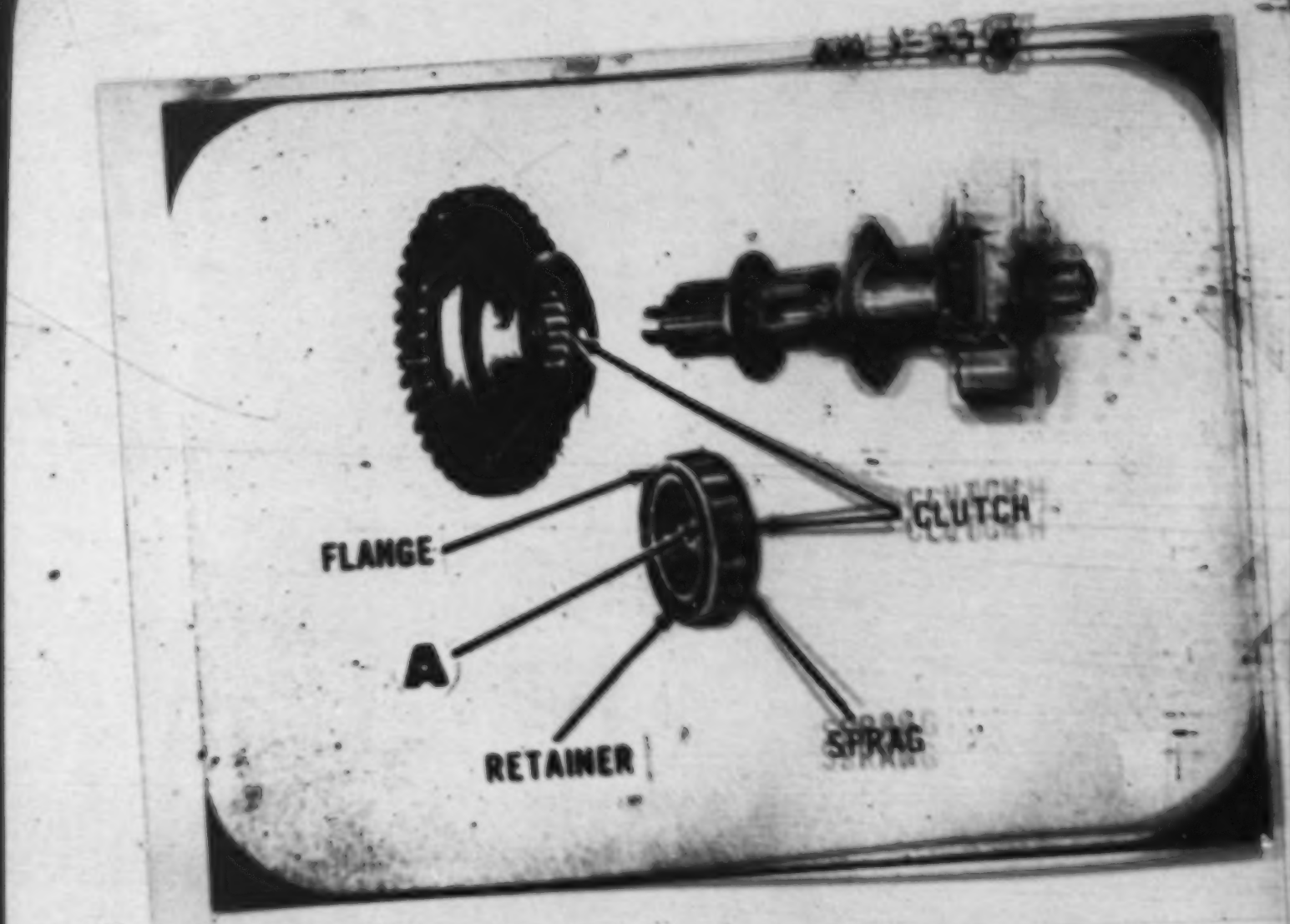
AM L27



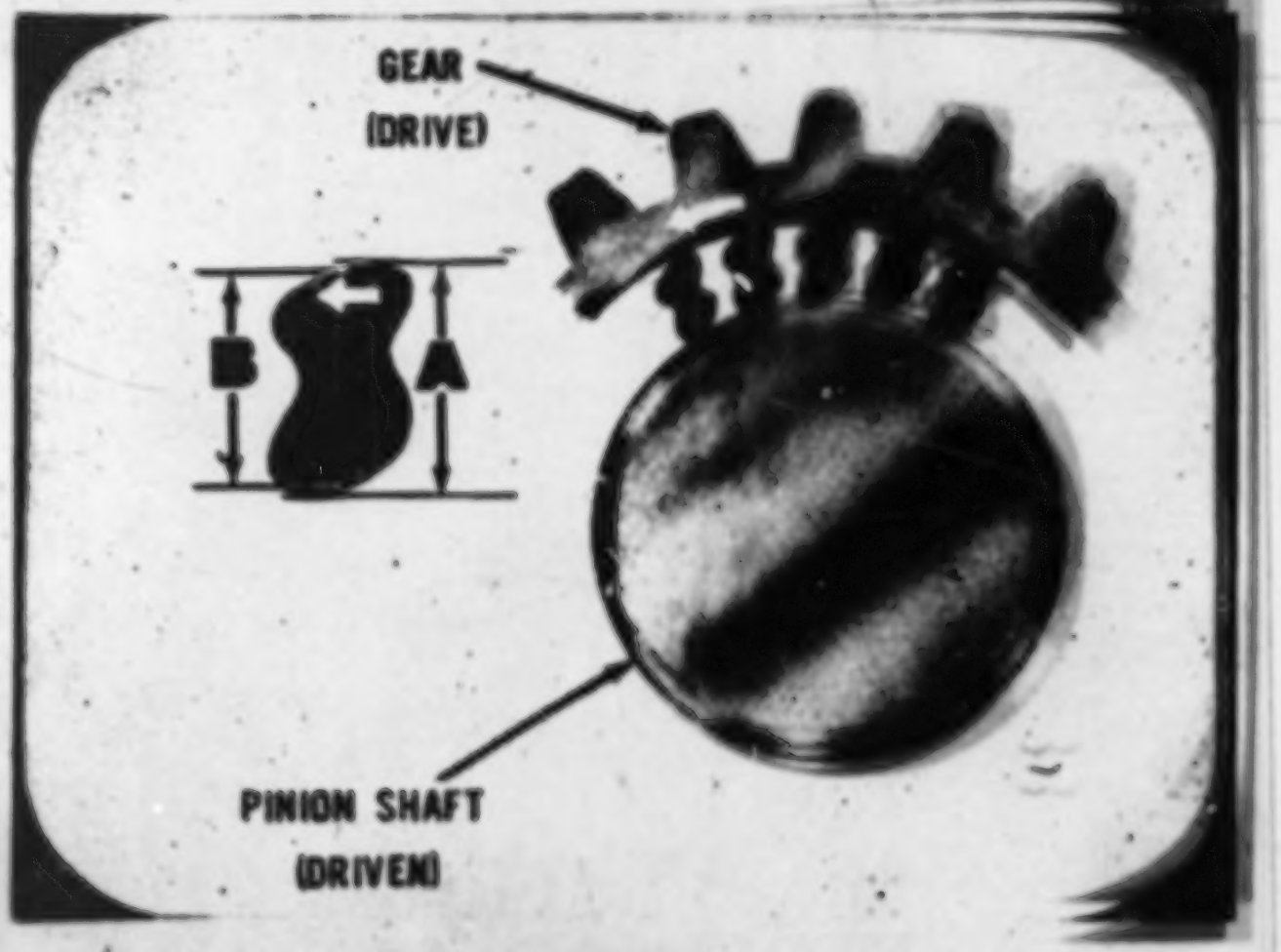

DRIVING DISC
PRESSURE PLATE




DRIVE GEAR
SHAFT
OVERRUNNING CLUTCH


CLUTCH
FLANGE
A
RETAINER
SPRAG

AM 1-33



INSTRUCTOR'S GUIDE

Title: I - CATERPILLAR STARTING (PONEY) ENGINE (PART I)
II - LEARNING ABOUT BRAKES (PART II

AM 1-27
9/23/66

OBJECTIVES:

1. To introduce to the student a new concept in engines, the gasoline engine that CAT uses to start the main engine.
2. To give the student some theory behind why the gasoline engine operates as it does.

LEARNING AIDS suggested:

VU-CELLS:
AM 1-27(1) (Clutch and starter pinion assembly positions)
AM 1-27(2) (Applying the brake)
AM 1-27(3) (In brake position)
AM 1-27(4) (Release yoke position)
AM 1-27(5) (Starter pinion)
AM 1-27(6) (Clutch cover plate)
AM 1-27(7) (Pressure plate)
AM 1-27(8) (Overrunning clutch-1)
AM 1-27(9) (Overrunning clutch-2)
AM 1-27(10) (Sprags-1)
AM 1-27(11) (Sprags-2)
AM 1-27(12) (Flame movement)

MODELS: Any cutaways, component parts, or assemblies of the poney engine that can be brought into class conveniently will be most helpful for explanation and demonstration purposes.

FILMSTRIPS: Note to instructor: The following filmstrips are available by request through your local Caterpillar distributor. Be sure to allow ample time for the request to be filled.

Audio Film No. 339B, Vertical Starting Engine - Caterpillar Tractor Co., Peoria, Ill.

QUESTIONS FOR DISCUSSION AND GROUP PARTICIPATION:

1. What type of ignition system does the CAT starting engine have?
2. Is the CAT starting engine self-contained? Explain.

QUESTIONS FOR DISCUSSION AND GROUP PARTICIPATION: (cont'd)

3. How does the starting engine promote easy starting of the main engine in cold weather?

4. Could this engine easily be adapted for another use other than a starting engine? Why not.

5. How is the magneto driven on this engine?

6. What prevents the starting engine from flying apart after the diesel engine starts?

7. In what part of this starting engine are the "sprags" located? What is their purpose?

8. What can happen if severe knocking occurs in a gasoline engine?

9. What does the compression ratio have to do with engine knocking tendencies?

10. Why does the disk brake have more friction area than the drum brake? Explain.

11. Explain how an electric retarding braking system operates.